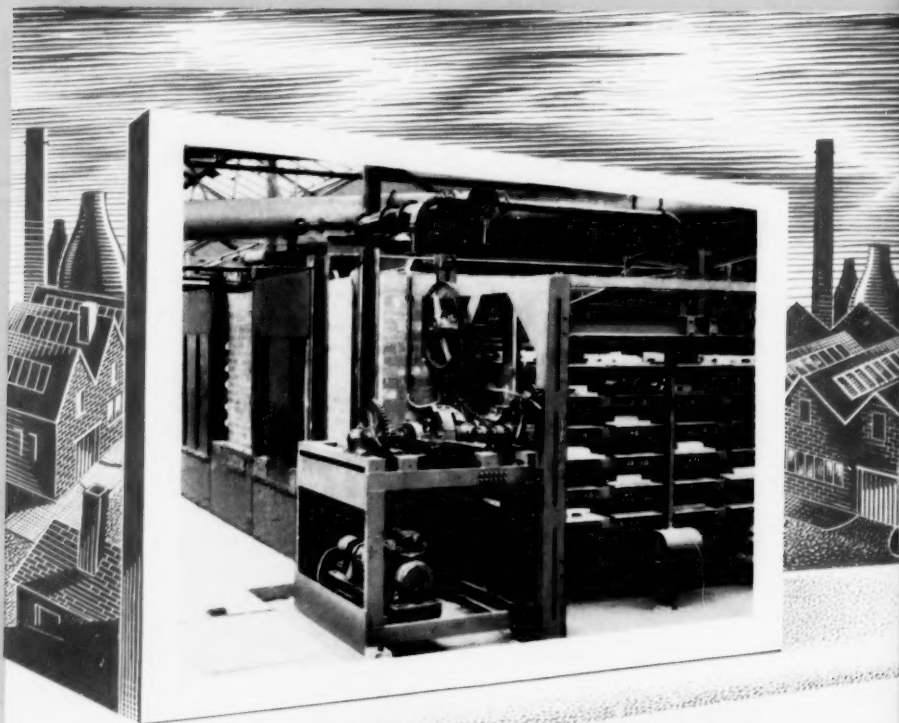


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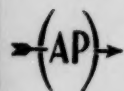
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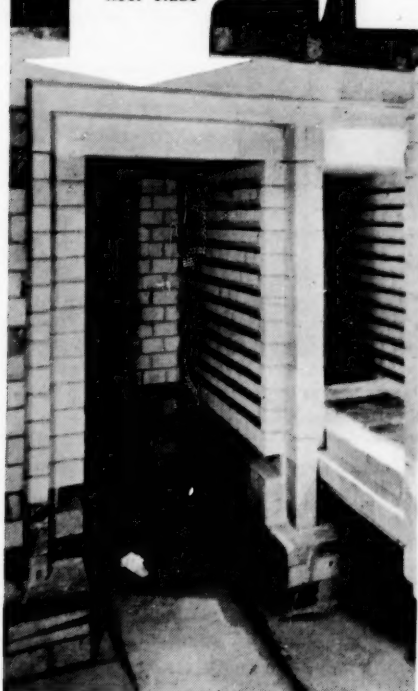
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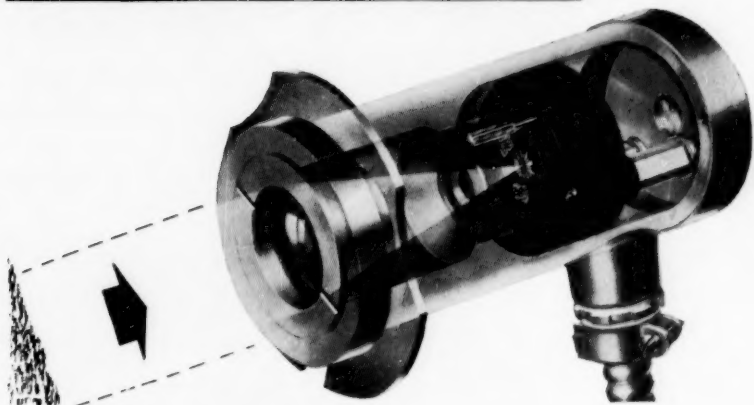
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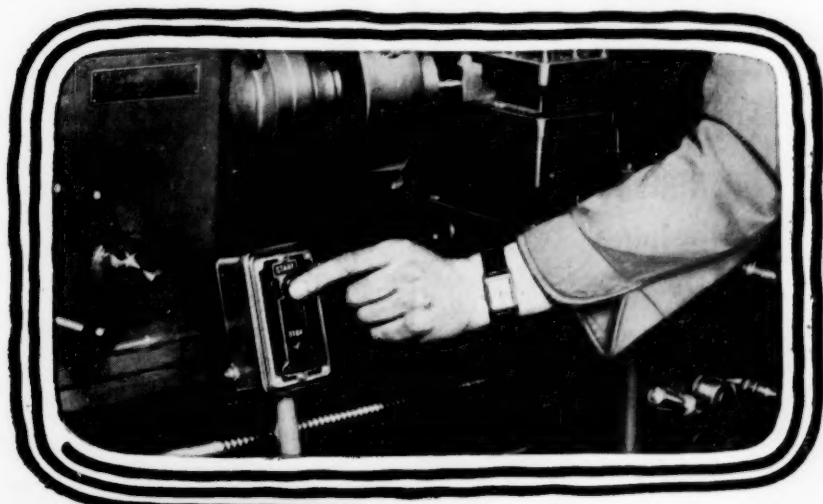
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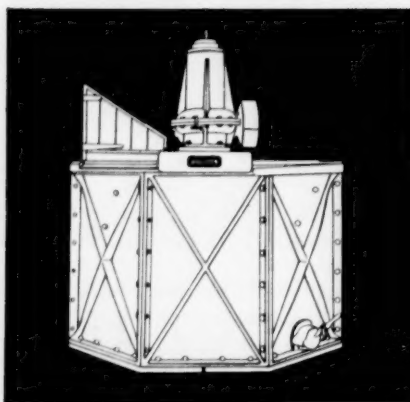
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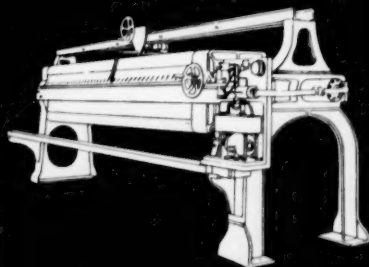
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JULY 1954

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VOL. VI

JULY, 1954

NO. 65

Productivity

THE need for higher productivity was fully realised in 1948 when Sir Stafford Cripps, then Chancellor of the Exchequer, formed the Anglo-American Council on Productivity to assist British industry to raise the level of its output. Mechanisation and careful time and motion studies, which largely account for American high productivity, have since been used to a far greater extent on this side of the Atlantic than hitherto.

The Production Exhibition staged recently in London, which is reported in this issue, is another step forward to bring Britain once more in line with the U.S. in the field of productivity. There is still room for the individual craftsman and we should rue the day he were to disappear. But greater efficiency can be introduced even into his work. Some features of the potters craft for example cannot be done better than by hand, but the preparation of tools and materials and even some of the applications can best be achieved by machine. The frequently expressed sentiment that what is hand made is necessarily best was not the spirit of some of the old craftsmen who though conservative were nevertheless glad to adopt labour saving devices.

The National Industrial Fuel Efficiency Service (N.I.F.E.S.) which held a press conference in London recently aims, as an aid to higher productivity, to encourage and assist in fuel saving by improved methods. One example of their help to industry is that of a brickworks which by lagging and transferring warm air to the brick dryer saved 70 tons of fuel oil annually. A government loan scheme enables firms to implement the recommendations of N.I.F.E.S. Up to £30,000 may be borrowed for a period of up to twenty years at commercial rates of interest. The establishment of N.I.F.E.S. is a great step forward in the search for greater efficiency and productivity.

The publishers of CERAMICS, Arrow Press Ltd., are also playing a part in this campaign. *Fuel Efficiency News*, the journal of the Ministry of Fuel and Power ceases publication in August. From September, the quarterly publication of Arrow Press Ltd., *Fuel Economist*, will appear monthly under the new title of *FUEL EFFICIENCY* and will absorb the circulation of *Fuel Efficiency News*. It has already established a close liaison with N.I.F.E.S. and will circulate to industrial and commercial establishments which between them consume more than 80 per cent. of the fuel used for these purposes in the country.

This publication should prove interesting to every branch of industry none of which can afford to ignore the problem of efficient fuel usage.

The Clay Minerals and their Identification

(SPECIALLY CONTRIBUTED)

THE nature of clay, with its peculiar properties, has been the subject of much speculation, and it is only in comparatively recent times that the advent of new apparatus and techniques has given us a better insight into the problem. One of the interesting things that has emerged is that, instead of being composed largely of amorphous material, clays contain rather minute crystals, which can be classified. Although our knowledge of these minerals is not complete, there is sufficient data available to give a picture of the main types present in clays, and in many cases their formulæ have been worked out.

Much of the work requires a good knowledge of physics and chemistry to be understood thoroughly, and the specialist will find good accounts of the work up to date in such books as *Clay Mineralogy*, by R. E. Grim (McGraw-Hill, London, 1953). The aim of this article, however, is to try to present an outline of some of the more important clay minerals found in common ceramic materials, and to indicate the methods which have been used in elucidating their structures.

Structural Concepts

To understand the latter it is necessary to enumerate certain elementary concepts on the forces which hold

atoms together. An atom consists of a nucleus having a positive charge and a number of negatively charged electrons surrounding it equal in number to the net positive charge on the nucleus. Atoms can gain or lose electrons to become negatively or positively charged ions. The electrostatic forces between such charged ions hold them together. For convenience these forces are referred to as bonds. The type of bond described above is referred to as an ionic bond. Where a pair of electrons is shared by two atoms the bond is called covalent. The bonds holding atoms together to form molecules are oriented in space. Those of silicon, from which the silicates are derived, are spaced in such a way that if the silicon atom were situated at the centre of a regular tetrahedron the bonds would radiate to the four corners (Fig. 1). Moreover, silicon atoms can join together to form chains, and in this way large molecules can be formed. Crystals are obtained when there is an orderly arrangement of the atomic species, and we have an orderly repetition of a simple pattern called a unit cell. Where this orderly arrangement does not obtain, glasses may be formed. In silicates the unit from which the structures are built up is the silicon atom linked to four oxygen atoms situated at the corners of a regular tetrahedron.

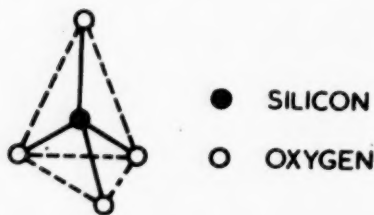


Fig. 1

Kaolinite $\text{Al}_2\text{Si}_2\text{O}_{10}(\text{OH})_2$

The potter is mainly concerned with three clay minerals, kaolinite, montmorillonite, and illite. Of these the first is the most important, and is often referred to in older books as clay substance. China clay is essentially kaolinite with various small amounts of quartz and mica as impurities. According to D. A. Holdridge (*Trans. Brit. Cer. Soc.*, 49, 289,

Fig. 2. Electron microscope photograph of kaolinite crystals, 50,000 X.

(By courtesy of English Clays Lavering, Pochin & Co. Ltd.)



1949-50), ball clay appears to consist of kaolinite in a more or less altered form. Electron microscope photographs have shown that kaolinite comprises crystals in the form of flat flakes with six sides giving a roughly hexagonal structure. The average diameter is somewhat under one micron, that is less than 0.001 mm., and the thickness is of the order of one-twentieth of a micron (Fig. 2).

Structurally, kaolinite is considered to be derived from a layer of hydrated alumina condensed with a chain of linked silicon tetrahedra. Such an arrangement can only be completely represented by a space diagram with a, b and c co-ordinates, but in the a-b plane Grüner has proposed the structure given in Fig. 3. The unit layers

of kaolinite are considered to be held together by secondary bonds between the hydroxyl (OH) ions of one layer and the oxygen ions of the other. This bond is relatively strong, and breakdown with penetration of water between the unit layers does not readily occur as it is supposed to do in montmorillonite (the principal constituent of bentonite). The latter swells in the presence of water, whereas kaolin and similar clays do not behave in this way. The characteristics of the kaolinite crystal have been measured. Examination of some English fireclays has shown the presence of poorly crystallised kaolinite. Names have been proposed for this, but Grim (loc. cit.) doubts whether a specific name for such material is justified.

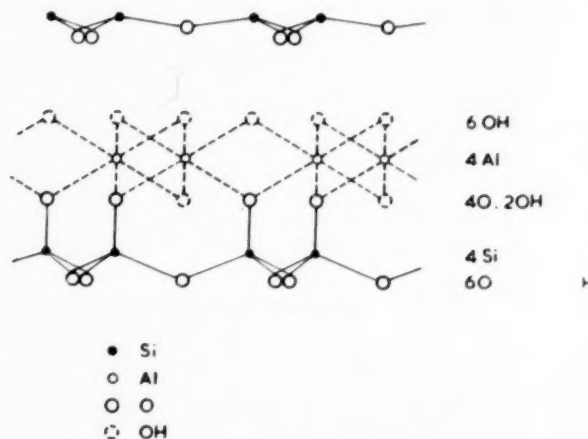


Fig. 3. Structure of kaolinite (after Grüner)

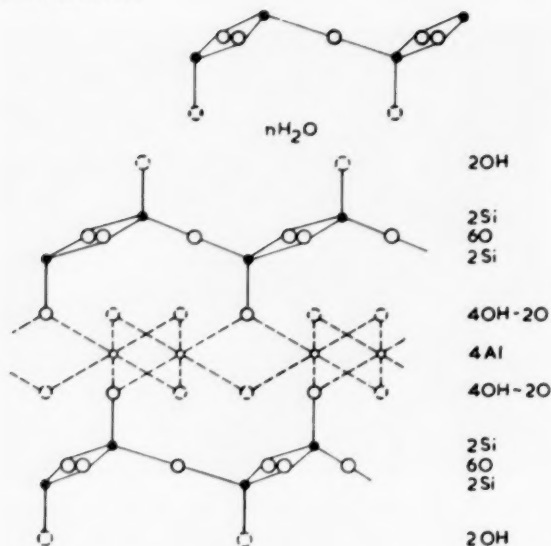


Fig. 4. Montmorillonite
(after Edelman and
Farejee)

Dickite and nacrite, which are rare constituents of clays, are similar to kaolinite and are believed to have similar structures. Halloysite contains twice as much water as kaolinite and has an unstable structure. Heating converts it to meta-halloysite, which has the same formula as kaolinite and has a similar structure. Halloysite and meta halloysite are present in numerous clays. They are very finely divided. They are usually classified with the kaolinite minerals.

Montmorillonite and Illite

As mentioned above, the former material is found in bentonite. It forms small plate-like crystals smaller than kaolinite (usually not more than 0.05 micron diameter). The structure consists of two layers of tetrahedral silicon-oxygen layers with a layer of Al-OH octahedra in between (Fig. 4). As mentioned previously, the residual bonds between the oxygens of each tetrahedral layer is weak, and consequently water can penetrate between the unit layers and cause swelling. These water layers can be one, two, three or four molecules thick. Other montmorillonite minerals include beidellite and nontronite, but these are not of great interest to the ceramist. Illite has a structure similar to that of montmorillonite, but some of the tetrahedral silicon atoms have

been replaced by aluminium. This results in a negatively charged unit, so that external positively charged cations of potassium K^+ are taken on. The unit layers are strongly bound together and swelling in water does not occur.

Methods Used in Identifying Clay Minerals

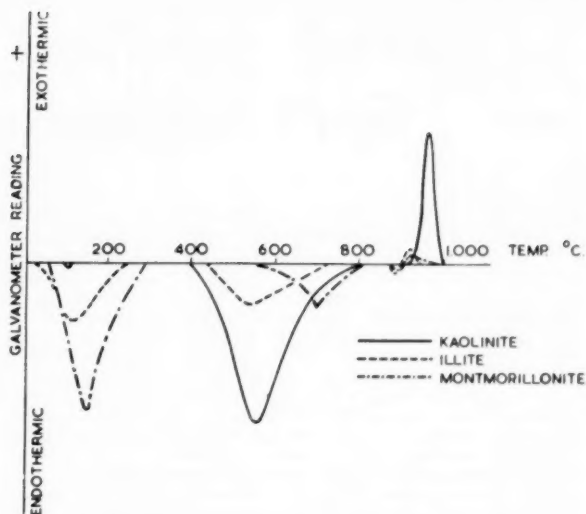
The identification of the clay minerals is not always easy, since the crystals are very small and not always well defined. The principal methods involved are X-ray diffraction, differential thermal analysis, and optical and electron microscopy. Probably the easiest to carry out with ordinary laboratory facilities is the differential thermal analysis. X-ray diffraction has a very wide application, since it can be done on finely powdered material. Electron microscopy has enabled us by its high magnification to photograph crystals that could not be made visible in the ordinary way.

It has confirmed the plate-like structure of crystals of clay minerals like kaolinite.

Differential Thermal Analysis (D.T.A.)

The principles of this method were described in an article in CERAMICS in 1952 (*Ceramics*, 4, 10, 1952). Briefly, the substance to be identified is heated side by side with an inert material

Fig. 5. Thermal analysis curve of kaolinite, illite and montmorillonite



(usually calcined alumina or calcined china clay). Thermocouples are placed in each material and connected in opposition so that no current flows in the external circuit until some change, either endothermic or exothermic, occurs in the material under examination. The thermal analysis curve is obtained by plotting the deflection against the temperature of the furnace (Fig. 5). The latter is obtained with an ordinary thermocouple in the usual way. To get reproducible results it is necessary to standardise the conditions of the experiments, especially as regards the packing density of the material under test and the rate of heating. Details of these are given in papers by F. H. Norton (*J. Amer. Cer. Soc.*, **22**, 54, 1939), R. E. Grim and R. A. Rowland (*ibid.*, **27**, 65, 1944) and R. W. Grimshaw, E. Heaton and A. L. Roberts (*Trans. Brit. Cer. Soc.*, **44**, 76, 1945), and others.

Mineral types are identified by the positions of the peaks in the thermal analysis curve. Kaolinite undergoes a decomposition at approximately 585° C. when water is lost. This is accompanied by an absorption of heat. The actual position of the peak depends on the rate of heating (cf. E. B. Colegrave and G. R. Rigby (*ibid.*, **51**, 355, 1952)), and emphasises the need for standardisation. There is also an exothermic reaction which commences in the region of 950° C.,

coinciding with the formation of crystalline γ -alumina.

F. H. Norton has shown by examining nacrite, dickite, kaolinite, anauxite, halloysite, and allophane that the kaolinite minerals as a class can be identified by the exothermic reaction at 980° C., and that the individual members can be identified by the endothermic effects (except anauxite). Montmorillonite has a less pronounced endothermic effect than kaolinite and the peak occurs at a higher temperature (approx. 700° C.). The exothermic effect is smaller and takes place at lower temperature, being preceded by a small endothermic effect. Illite has a smaller endothermic effect at a similar temperature to kaolinite. The exothermic effect is smaller, and at a different temperature. Thermal analysis curves below 200° C. are difficult to reproduce on account of adsorbed water being present. It has been shown to be possible to detect particular clay minerals in mixtures of clays by this method. It is also possible to use the method for the approximate determination of the amount of a material present. For details of these applications the article previously referred to should be consulted.

Optical and Electron Microscopy

The petrological microscope can be used to identify clay minerals

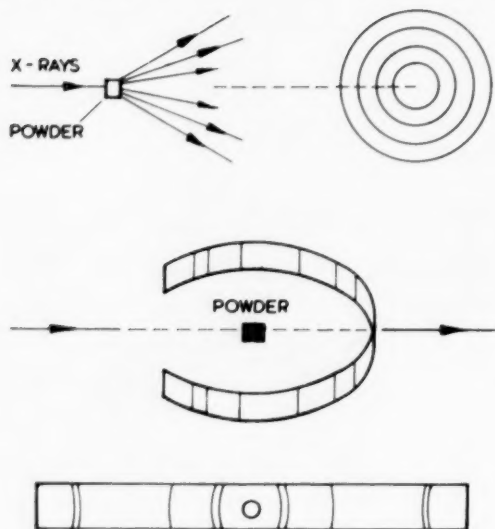


Fig. 6. Principle of X-ray diffraction (after Richardson (op. cit.))

provided the particles are large enough to be visible. Often, however, this is not the case when the crystals are poorly defined, and it then becomes necessary to use the electron microscope to make the individual crystals visible. The lower limit of visibility in the microscope is given as 0.2μ ($\mu = 10^{-3}$ mm.). Where the particles are smaller it is necessary to use a different means of rendering them visible. This is given by a stream of electrons which can excite a fluorescent screen. A small object placed in the path of the rays can thus be rendered visible by scattering the electrons as they pass through the sample. Direct magnifications of between 3,000 and 15,000 are obtained with the electron microscope and by photographic enlargement of the image this figure can be increased several times. By a special technique the shadow cast by the crystal when illuminated obliquely can be used to find its thickness. The technique is a highly specialised one, and a good set of references covering this is given in R. E. Grim's book (op. cit.).

Electron microscopy has enabled the shapes to be seen and dimensions of some of the clay minerals to be measured. The apparatus is, however, costly and the technique a specialised one.

Electron Diffraction

The powder method of X-ray analysis was developed by P. Debye and P. Scherrer in Germany and A. W. Hull in the United States. It is a very valuable means of identifying ceramic products in which crystals are often not well developed. The finely-powdered material is irradiated with an X-ray beam of known wavelength. The specimen is usually rotated and reflects a series of X-ray beams in the form of cones from the crystals. These form a series of circles on flat photographic paper placed in front or behind the specimen and on developing a series of black rings results. More usually the sensitive paper is placed round the specimen in the form of a cylinder and then the reflected beams form arcs of circles (Fig. 6). Each crystalline substance will reflect the rays according to the arrangement of atoms in it, and thus the photographs obtained may be used to identify the substance present, just as identity photographs and fingerprints are used. It is also possible to determine the group of crystal to which the individual belongs.

X-ray crystallography has been of the greatest assistance in systematising the study of clay minerals. It has

(Continued on page 222)

Thick Insulating Ceramic Coatings for Metal

THE service life and efficiency of metal structures operating at elevated temperatures has been improved by the use of glassy ceramic coatings which retard the rate of oxidation of the metal. These coatings also provide a minor degree of thermal insulation for the underlying metal and are most efficient in this respect when used in conjunction with some method of cooling the metal structure, e.g., the use of ceramic coatings on cooled gas turbine stator or rotor blades.

At the present time, the insulating effectiveness of crystalline ceramic coatings is limited mainly by a maximum serviceable thickness of application of 20-25 mils. A requirement, therefore, exists for the development of a much thicker insulating coating which would be capable of reducing metal operating temperature by several hundred degrees. The development of such a coating would permit the use of non-strategic materials at significantly lower operating temperatures at which the metals would have better strength and oxidation resistance.

Experiments have been made in the application of thick coatings to metals* and this article analyses the potentialities of such coatings and deals with a suggested method of coating application which appears to offer promise in providing thermal insulation for metals at high temperatures.

Basic Considerations

The fact that there does not exist at present a satisfactory thick refractory insulating coating capable of withstanding high temperature erosive exhaust gases is an indication of the difficulties which are encountered in attempting to apply great thickness of ceramic materials to metal.

Adherent glass type coatings are produced at temperatures of approximately 1,500-2,000° F. depending upon the solution and viscosity characteristics of the glass and the rate of oxidation of the metal. Upon cooling, the differential contraction which occurs between the metal and glass, at temperatures below the strain point of glass, generally produces compressive stresses in the coating

which are counter-balanced by tensile forces concurrently generated within the metal structure. These residual stresses, if sufficiently high, may cause failure of the coating by spalling. Coatings having excessively high residual compressive stresses are generally less durable when applied in greater thicknesses, i.e., they less readily assist mechanical impact, flexure and thermal shock.

Insulating crystalline top coatings which are less glassy in nature than porcelain enamels may exhibit shrinkage during initial firing and/or during operation at elevated temperatures. The development of shrinkage cracks leads to curling, flaking and general deterioration of the coating during the cooling cycle. Here again this defect is less pronounced for thinner coatings. The coefficient of thermal expansion of this type of coating is also decreased at high temperatures by solution of the refractory constituent in the bonding glass, thus altering the fit of the coating to the metal.

Many of the problems outlined above have been minimised, to some extent, in the field of decorative porcelain enamels. Research efforts have been directed toward the contrary objective of producing thinner, though more opaque enamels. Coatings have been formulated which are more economical in production and which have improved impact resistance, higher spall resistance, and better adherence. On the other hand, very little background of commercial experience is available in the technology of thick insulating ceramic coatings.

Experiments have been made with extremely high firing coatings for Inconel in which the composition of the metal ceramic insulating coating varied from practically pure nickel at the metal interface to 100 per cent. ceramic at the coating surface. For a particular coating in which electrically fused MgO was used, difficulty was encountered in obtaining a hard dense non-friable surface. The addition of fluxing agents to the composition of the outer coating layer caused an excessive amount of firing shrinkage.

Another metal-ceramic coating which was tested experimentally in many applications consisted of nickel metal and magnesium oxide which were pre-sintered, reground and then applied by flame spraying. The most effective thickness was reported as 0.025 in. The insulating

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value of metal-ceramic coatings is, of course, adversely affected by increased metal content.

A porous silica insulating coating applied on the inside surface of a turbo-jet engine combustion chamber liner was found to erode badly when tested. The desirable characteristics of high porosity coatings (namely, low bulk density and low thermal conductivity) are partially offset by their generally lower strength and poor erosion resistance. Refractory wash coats have been used for the porous surface of insulating fire brick. These coatings prevent mechanical abuse and penetration of the brick by destructive elements in the fuel. The use of a similar treatment for porous insulating coatings offers a possibility of reducing flame erosion.

Crystalline insulating top coats applied over a base coat enamel on metal have been reported. Here again the maximum thickness appears to be 0.025 in. At greater thicknesses of application severe flaking and spalling occurs on heating and is probably due to residual stress

concentrations produced by differential dimensional changes between the coating and the metal. A study of the effects of mill additions on the thermal expansion properties of top coats has indicated that the coefficient of thermal expansion of diaspore top coatings will decrease if the bonding glass becomes fluid enough to dissolve some of the crystalline components. This phenomena is believed to be partly responsible for failure of top coats by flaking and spalling at elevated temperatures. The insulating effectiveness of these crystalline top coats has been determined. Less severe temperature gradients and metal operating temperatures from 50-100° F. lower than that of bare metal were noted for an experimental combustion chamber 1 in. in dia. and 6 in. long and coated on the inside only with maximum thickness of coatings (Fig. 1).

The following physical properties should be considered in outlining the physical characteristics required of a serviceable high-temperature insulating coating:

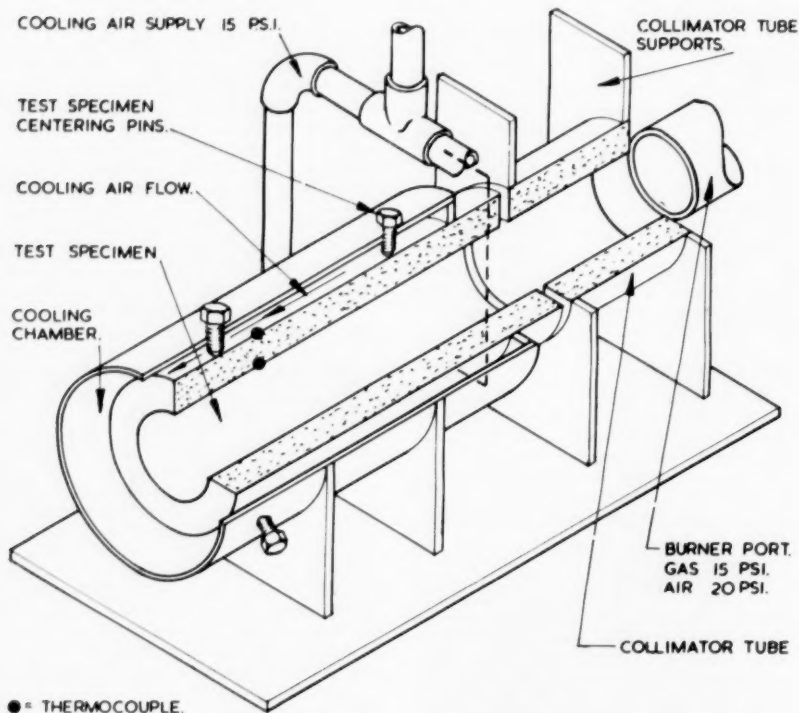
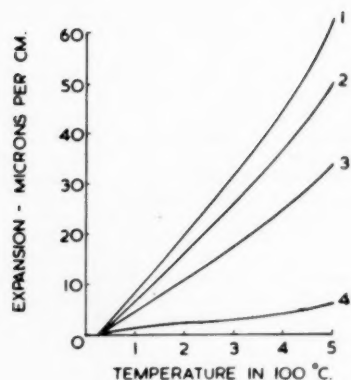
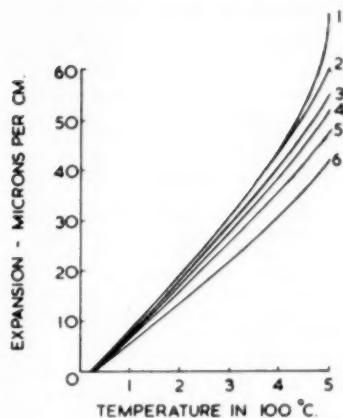


Fig. 1. Diagram of experimental combustion chamber



NO.	PERCENT FRIT.	PERCENT $Al_2O_3 \cdot TiO_2$
1.	100	0
2.	50	50
3.	20	80
4.	0	100



NO.	TOP COAT.	% DIASPORE
1.	117 - 42	10
2.	117 - 43	20
3.	117 - 44	30
4.	117 - 45	40
5.	117 - 46	50
6.	117 - 47	70

(Left) Fig. 2. Thermal expansion of various aluminium titanate-Frit. No. 172 compositions. (Right) Fig. 3. Thermal expansion of topcoats containing various percentages of diaspor as a mill addition

1. Adherence
2. Thermal insulation
 - (a) Conductivity
 - (b) Diffusivity
 - (c) Emissivity
3. Refractoriness
4. Thermal shock resistance
5. Erosion resistance
6. Compressive strength
7. Bulk density

Adherence will depend on the method of attaching the refractory insulation to the metal and may be obtained in a number of ways, such as, by mechanical attachment, by a flame sprayed metal bond, by conventional enamel adherence bond, or by other methods of obtaining a metal-ceramic seal.

High thermal insulation and refractoriness are primary requisites. If a highly porous structure can be obtained the thermal insulation offered by a material of given thermal conductivity can be greatly increased. However, the softening point (or PCE) of the coating should be high enough to prevent further vitrification and shrinkage of the porous structure.

Desirable thermal shock properties may well be obtained by the use of materials having low thermal expansion, such as aluminium titanate, but only after successfully solving the serious problem of

obtaining adequate adherence between the metal and ceramic.

Erosion resistance, strength and bulk density are interdependent. For a given material, increased erosion resistance and strength require a body high in bulk density, while considerations for lighter weight and lower heat transfer prescribe a material of maximum porosity and lowest bulk density.

Due to the apparent conflict of some of the above requirements, they may only serve as guides in developing techniques and compositions for thick insulating coatings. A determination of a more exact relation among these various criteria must necessarily be based upon the test of coated components operated under actual service conditions.

Where an increase in the weight of a metal component operating at elevated temperatures is necessitated by the use of thick insulating coatings, design changes warranted by possible reduction in metal operating temperatures may permit some weight decrease in other areas. For these reasons, a high weight factor should not be allowed to rule out an otherwise promising coating during the early stages of its evaluation.

Scope of the Investigation

The work described here was limited to exploratory experiments in the

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preparation of thick insulating coatings unique either in composition or in technique of application. The preparation of the following types of coatings was attempted (each is discussed later):

1. Graded Expansion Top Coats
2. Rammed in Place Coatings
3. Dry Formed Coatings
4. Enamel Bonded Porous Insulating Bodies

Owing to the varied nature of the coating techniques and specimen shapes used it was not possible to make more than a qualitative correlation of the relative merits of each type of coating. Long heat tests were performed only on the graded expansion top coats. In those cases where combustion tubes were satisfactorily coated with thick insulating coatings, they were evaluated in the simulated combustion chamber test stand rig.

Graded Expansion Top Coats

The possibility was considered of using thermal shock resisting materials having a very low coefficient of thermal expansion. In applying thick top coats of this type it was felt that residual stress concentration could be minimised by applying successive layers of top coats, the coefficients of expansion of which varied from nearly that of the metal to considerably lower values at the coating surface. Thermal expansion curves (obtained from interferometer data) are shown in Fig. 2 for several glass bonded coatings containing frit No. 172 and various percentages of aluminium titanate, and in Fig. 3 for coatings containing frit No. 117 and various percentages of diaspore. By application of these coatings in the order of increasing crystalline content a graded expansion coating may be obtained.

TABLE I.
Frit Formulations.
Raw Batch Weights

Frit	285	32	117
Potash Feldspar, Keystone	30.2	34.9	34.9
Quartz	21.2	24.3	—
Borax	21.0	23.9	9.1
Soda Ash	5.3	6.5	16.4
Soda Nitre	4.0	4.2	4.2
Fluorspar	3.2	3.7	—
Cobalt Oxide	—	0.5	—
Nickel Oxide	—	0.5	—
Manganese Dioxide	—	1.5	—
Sodium Silicofluoride	—	—	4.2
Zinc Oxide	—	—	9.1
Aluminium Hydrate	15.1	—	—
Aloxite (Al ₂ O ₃)	—	—	3.8
Calcium Carbonate	—	—	8.0
Barium Carbonate	—	—	0.7
Vanadium Pentoxide	—	—	2.7
Barium Metaphosphate	—	—	6.9

Metal Compositions—Percent.

Frit	285	32	117
SiO ₂	51.1	56.5	27.2
Al ₂ O ₃	19.8	8.4	13.0
B ₂ O ₃	9.6	10.5	4.0
Na ₂ O	10.9	12.2	16.2
K ₂ O	4.6	5.1	5.2
CaF ₂	4.0	4.5	—
CoO	—	0.6	—
NiO	—	0.6	—
MnO ₂	—	1.8	—
V ₂ O ₅	—	—	3.0
CaO	—	—	5.4
BaO	—	—	6.0
ZnO	—	—	11.0
Na ₂ SiF ₆	—	—	5.0
P ₂ O ₅	—	—	4.0

TABLE 2.

Mill Batch Compositions (Parts by Weight) and Measured Thermal Expansion Coefficients (cm./cm. ° C. by 10³) of Graded Expansion Top Coats.

Coating No. ¹	285-1	32-22	117-42	117-43	117-44	117-45	117-46	117-47
Frit	100	88	90	80	70	60	50	30
Diaspore ²	—	12	10	20	30	40	50	70
X-Brand Clay	7	7	7	7	7	7	7	7
Borax	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Water	50	45	45	45	45	45	45	45
<i>Cubical Expansion Coefficients³</i>								
100-300° C.			343	343	321	292	281	250
100-400° C.			360	360	335	311	293	260
100-500° C.			488	403	365	342	315	278

1. Coatings No. 285-1 and 32-22 were milled to a fineness of 4-6 gm. dry residue on a 200 mesh screen from a 100 gm. weighed sample slip. All top coats which contained diaspore were milled to a fineness of 0-1 gm. on a 200 mesh screen.
2. First grade diaspore (nominal composition $Al_2O_3 \cdot H_2O$) containing 70 per cent. Al_2O_3 .
3. Note decreasing expansion as frit is replaced by diaspore.

In preparing interferometer cones for the determination of the thermal expansion curves it was noted that a glass content of less than 30 per cent. produced weak and friable pellets when heated at 1,650° F. for 10 min. The thermal expansion curves for coatings containing various percentages of diaspore and aluminium titanate, a material having an extremely low coefficient of thermal expansion, were nearly identical for a glass content greater than 30 per cent. For this reason graded expansion top coats were compounded using diaspore rather than aluminium titanate, which required the expenditure of considerable time in its preparation. Composition of all frits used are given in Table 1; those of the base and top coat mill batches are given in Table 2.

Low carbon 16 gauge steel specimens 2 in. by 4 in. were scaled for 3 min. at 1,400° F. in an electric furnace to burn off any grease or oil and to provide an easily sandblasted surface. After being sandblasted the metal specimens were dipped in base coating slip No. 285-1, set to pick up 40 gm. of dry slip per sq. ft. of surface area, and were then fired for 6 min. at 1,650° F. This base coat was approximately 3 mil in thickness.

Each layer of the various top coats was applied to both sides of the base coated samples by dipping, drying and firing for 6 min. at 1,650° F. Variation was attempted in the order of application of the six basic coating compositions. These compositions contained 10, 20, 30, 40, 50 and 70 per cent. diaspore and possessed decreasing coefficients of thermal expansion.

Twenty-eight laminated coatings were formed, using unique combinations of the above compositions. The more promising of these were applied in heavier weights of application by increasing the dry weight pick-up of each individual coating slip from 65-110 and finally 140 gm. per sq. ft. The thickness of fired coatings was determined by micrometer measurements of coated and uncoated specimens. Long heat tests of 72 hours duration were conducted on each individual laminated coating at 1,400° F. and later, on the same specimens, at 1,600° F. The test consisted of placing the 2 in. by 4 in. coated specimens in an Inconel rack inside an electric furnace at the test temperature; during the 72 hour test period the samples were withdrawn from the furnace for a total of twenty-four 15 min. periods.

A tabulated summary of all coating compositions in Table 3 indicates the order of application of the top coat compositions, the dry weight pick-up for each successive layer, total fired thickness of coating and results of the 72 hour long heat tests at 1,400° F. and later, on the same specimens, at 1,600° F.

Several of the more promising graded expansion top coats were applied over base coat No. 285-1 to the inside surface of 2½ in. dia. steel tubes. A dry weight pick-up of 110 gm. per sq. ft. for each lamination of top coat was used. Unusual coating difficulties occurred in applying top coats to these surfaces. For example, the laminated coating consisting of successive layers of top coats each containing respectively 70, 50, 30 and 10 per cent. of diaspore (balance, No. 172 glass

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frit) exhibited shrinkage and curling during firing of the essentially glassy 10 per cent. diaspore coating which constituted the outer layer. Other similar coatings developed either shrinkage cracks or a general flaked appearance. These defects were not apparent in the coating of flat 2 in. by 4 in. specimens.

The tubes coated with the two most satisfactory coatings (total laminated thickness—40 mil and 50 mil respectively) were torch tested in the flame tube apparatus. Curves for time versus temperature of inner and outer surfaces are illustrated in Fig. 4. Similar curves are shown for an identical tube coated only with base coat for comparison purposes. Temperature measurements were made by chromel-alumel thermocouples spot-welded to the outer metal surface and cemented with alundum cement to the inner ceramic surface. Due to minor differences in the shape of specimen tubes, and eccentricities in aligning the specimen axis with the flame axis, it was impossible to produce equivalent inner surface temperatures.

However, temperature differentials of 150-300° F., which occurred between inner and outer surfaces of coated specimens, when compared with a temperature differential of almost 100° F. for a base coated specimen, provide an indication of

the insulating effectiveness of the coatings. The coating 50 mil in thickness melted and tended to crawl and form beads. This coating was observed to have very fine hairline cracks prior to testing, which were undoubtedly associated with its failure.

Crystalline insulating graded expansion top coats have been formulated and applied to low carbon steel over base coat No. 285-1. Although some flaking and spalling occurred immediately after firing, especially among the highly crystalline coatings applied at maximum thickness, it was possible successfully to apply coatings up to 80 mil in thickness on small flat specimens. It is interesting to note that adherent coatings were obtained when they were applied in increasing as well as decreasing order of thermal expansion. When applied to curved base coated sheet metal pieces the above top coats showed a tendency to shrink and pull away from the underlying coatings. It is possible that closer regulation of the thickness of application might tend to overcome this difficulty.

A sharp difference could be noted in the results of long heat tests on graded expansion top coats tested at 1,400° F., which were practically unaffected as compared with those tested at 1,600° F., which showed considerable flaking and

TABLE 3.

Summary Data on Graded Expansion Top Coats Applied on 1,020 Low Carbon Steel over Base Coat No. 285-1.

A. Coating slips set to pick up 65 gm./sq. ft. on a base coated steel plate.

<i>Coating Sequence in Terms of per cent. Diaspore (remainder = per cent. frit).</i>	<i>Total thickness (mil).</i>	<i>Remarks on 72 hr. long heat tests, 1,400-1,600° F.</i>
40	10 Edges burned	Coating peeled back at edges
40, 40	19 Unaffected	Light burn at edges
40, 40, 40	46 Unaffected	Light burn at edges
40, 40, 40, 40	49 Unaffected	Severe flaking, metal oxidised
40, 30	26 Unaffected	Severe flaking, metal oxidised
40, 30, 20	61 Black specked appearance	Very light burn at edges
40, 30, 20, 10	80 Black specked appearance	Very light burn at edges
10	9 Burned edges, slag spots	Burned edges
10, 30	15 Burned edges, slag spots	Flaking, metal oxidised
10, 30, 50	25 Light burn at edges	No further change
10, 30, 50, 70	53 Flaking in large areas	Coating gone, metal oxidised
70	10 Unaffected	Coating flaked, black matt appearance
70, 70	29 Light flaking at edges	Flaked and burned edges
70, 70, 70	—	—
70, 70, 70, 70	—	—
70, 50	28 Light flaking at edges	Some flaking, black matt appearance

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70, 50, 30	58 Top coating spalled	No further change
70, 50, 30, 10	75 O.K., light specking	No further change
50	11 Light burned edges	Top coat gone, metal oxidised
50, 50	26 Flaking in one corner	No further change
50, 50, 50	54 Light Flaking	Top coat gone on one side
50, 50, 50, 50	59 Light flaking	Top coat gone on one side
10	8 Brown discoloration	Burned edges
10, 20	15 Brown discoloration	Burned edges
10, 20, 30	22 Slight darkening, light burn at edges	No further change
10, 20, 30, 40	34 O.K., few brown specks	Flaking in one corner
10, 20, 30, 40, 40	67 Flaked off to base metal	Metal oxidised
10, 20, 30, 40, 40, 40	66 Light chip on one corner	Coating flaked off four corners, metal oxidised

B. Coating slips set to pick up 110 gm./sq. ft. on a base coated steel plate.

40, 30, 20, 10	43 O.K.	O.K.
40	13 O.K.	Light burn at edges
40, 40	23 O.K.	Moderate flaking in one corner
40, 40, 40	37 O.K.	O.K.
40, 40, 40, 40	77 O.K.	Flaking on both sides, metal oxidised
10	14 Light burn at edges	Brown discoloration burned edges
10, 30	30 Light burn at edges	Moderate burn at edges
10, 30, 50	49 Very light burn	Flaking at one end
10, 30, 50, 70	103 ¹ Complete spalling of 70 coating	No further change
70	20 O.K.	Moderate flaking, both sides
70, 50	25 O.K.	Moderate flaking, both sides
70, 50, 30	34 Minor flaking	All top coats flaked off
70, 50, 30, 10	60 O.K.	All top coats flaked off
70, 70	24 O.K.	Moderate flaking
70, 70, 70	33 Light flaking on one corner	Moderate flaking
70, 70, 70, 70	—	—
10, 20	13 Burned edges	Coating darkened
10, 20, 30	23 Light burn	No further change
10, 20, 30, 40	36 Light burn	No further change
10, 20, 30, 40, 40	49 O.K.	Flaking at one corner
10, 20, 30, 40, 40, 40	82 O.K.	Flaking at corners

C. Coating slips set to pick up 140 gm./sq. ft. on a base coated steel plate.

40	19 O.K.	Flaked area on one side burned edges
40, 30	35 O.K.	Very light burn at edges
40, 30, 20	50 O.K.	Very light burn at edges
40, 30, 20, 10	65 O.K.	Light flaking and burned at edges
40, 40	37 O.K.	Flaked corner
40, 40, 40	72 O.K.	Flaked along one edge
10	15 Light burn at edges	Badly oxidised edges
10, 20	26 Light burn at edges	Badly oxidised edges
10, 20, 30	48 Edges slightly darkened	Flaking at edges
10, 20, 30, 40	47 O.K.	Edges slightly darkened
10, 30	30 Light burn at edges	Burned edges, coating blistered
10, 30, 50	49 O.K.	Very light burned edges
70	20 Minor flaking	All coating flaked off
70, 50	38 Coating flaked off one	All coating flaked off

¹ These coatings exhibited spalling or flaking immediately following the firing of the top coat and were not tested.

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oxidation (see Table 3). The effect of thermal spalling in producing coating failure should not be overlooked; however, it appeared that an appreciable portion of top coat failure was caused by absorption of the base coat into the top coat and oxidation of the metal surface. This is especially true for the porous high diaspore coatings. When this occurred, differential thermal expansion between metal and ceramic apparently provided the stress necessary to cause flaking.

On the basis of these and many previous high temperature tests on top coated specimens, the desirability of reducing the metal operating temperature below 1,400° F. was emphasised. Unfortunately, soak-type long heat tests in which the base metal and ceramic coating eventually reach the same equilibrium temperature, do not completely evaluate the effectiveness of thick insulating coatings. In this type of test no provision is possible for determining the effect of the coating in reducing metal operating temperatures to the level at which adequate metal oxidation resistance can be provided by the base coat. From the results of flame tube tests on graded expansion insulating coatings it would appear that a sufficient reduction in metal operating temperatures might be possible with present or improved-type coatings substantially to remove the possibility of top coat flaking.

Rammed in Place Coatings

Rammed in place coatings were investigated in an attempt to form a ceramic material $\frac{1}{2}$ in. or more in thickness which would adhere to a metal structure. For convenience in forming and testing, low carbon steel tubes $2\frac{1}{2}$ in. in dia. and 7 in. long, coated on the inside with 3 mil of base coat No. 285-1, were used as the supporting structure for the ceramic material. A wooden mandrel 7 in. in length and tapering in dia. from $1\frac{1}{2}$ in. at one end to $1\frac{1}{4}$ in. at the other was centred within the steel tube. This mandrel served as a core, about which the coating materials were rammed by hand, using a $\frac{3}{8}$ in. dia. tamping rod and hammer. All compositions contained an added eight

parts per 100 of Resinox,* a thermo-setting organic binder. Each assembly after being prepared by the method described, was placed in an electric oven at 450° F. for a period of two hours.

The composition containing aluminium titanate and Resinox was tested as a combustion chamber on the gas torch test stand. During the 20 min. test period all the Resinox bonding agent burned out; however, no erosion occurred. The inner surface of the aluminium titanate was slightly reduced as shown by a bluish discoloration indicating the presence of an oxygen deficient form of titania. Chromel-alumel thermocouples were properly placed to obtain the temperatures of the metal surface and inner combustion surface. The time-temperature curves for this 20 min. run are shown in Fig. 5. They indicate a total temperature drop of 1,050° F. with a maximum inner surface temperature of 2,100° F. After cooling this assembly it was noticed that the aluminium titanate insulation was soft and friable. The inclusion of 20 per cent. of No. 172 top coat bonding glass in the above composition served to form a satisfactory bond but caused an undesirable firing shrinkage to occur during a 15 min. test.

Experiments with rammed type coatings have indicated the greater insulating effect which are possible with ceramic coatings approximately $\frac{1}{2}$ in. in thickness. The requirement for the development of a proper bond within the ceramic insulating material is emphasised by the continued shrinkage of unfired glass bonded materials of the type investigated. For thicker coatings the problem of firing shrinkage is more severe since the greater amount of thermal insulation provided by these coatings retards the flow of heat and produces higher equilibrium temperatures at the inner combustion surface. This in turn necessitates a more refractory bonding phase.

A significant increase in weight corresponding to approximately $4\frac{1}{2}$ lb. per sq. ft. of flat surface is entailed in the use of dense thick insulating coatings such as

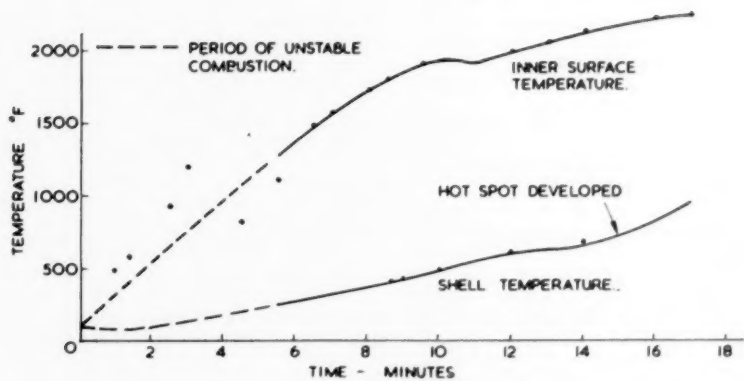
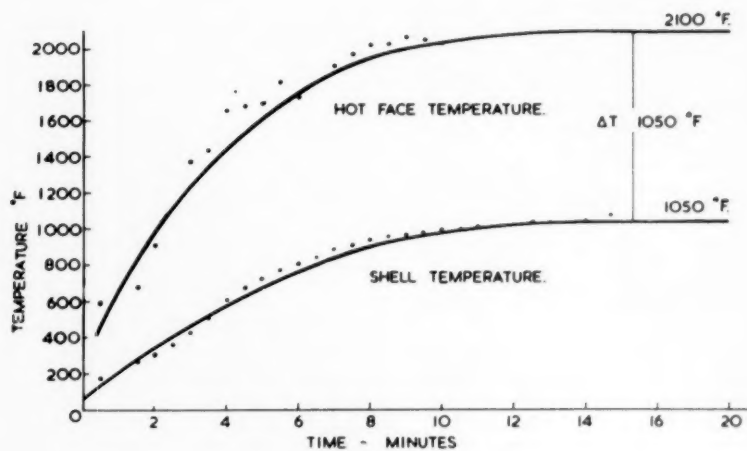
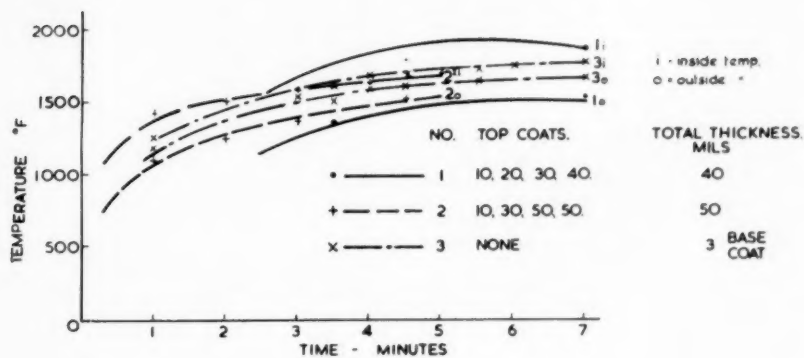
*A product of Monsanto Chemical Co.



(Top) Fig. 4. Inner and outer surface temperatures for $2\frac{1}{2}$ in. diameter steel cylinders coated with composite diaspore containing graded expansion top coats applied over base coat No. 285-1. Cylinders were heated internally by a gas-air flame

(Centre) Fig. 5. Time-temperature curves for inner and outer surfaces of $2\frac{1}{2}$ in. diameter gas-air combustion tube featuring $\frac{1}{2}$ in. thick rammed aluminium titanate-Resinox coating

(Bottom) Fig. 6. Time-temperature curves for inner and outer surfaces of a $4\frac{1}{2}$ in. diameter gas-air combustion chamber. The chamber consists of a glazed insulating tile bonded to the inside of the metal shell with an enamel type glass



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the aluminium titanate-Resinox composition discussed above. Consequently, for those applications in which weight considerations are of paramount importance the development of light weight, high porosity insulating materials may be required.

Dry Formed Coatings

Thick diaspore coatings bonded by No. 172 bonding glass frit were formed in a manner somewhat similar to that employed in preparing the rammed coatings. A lighter weight coating having a large degree of porosity was desired.

Low carbon steel tubes $2\frac{1}{2}$ in. in dia. and about $2\frac{1}{2}$ in. in height were coated throughout with 3 mil. fired thickness, of base coat No. 285-1. Coating slip 1104M-1* was applied without firing to the inner surface of the tube. The tubes were then set upright on a rectangular piece of 16 gauge stainless steel. Paper sleeves approximately $1\frac{1}{4}$ in. in dia. and $2\frac{1}{2}$ in. long were prepared and placed on the steel sheet inside of each tube and concentric with it. The centre of the paper sleeve was filled with coarse blasting sand; the annulus between the paper sleeve and the coated steel tube was filled with the pre-mixed dry loose coating materials, which consisted of mixtures of 55-75 per cent. diaspore and 45-25 per cent. frit No. 172. These specimens were fired on the stainless steel sheet in an electric furnace for 10 min. at 165° F. Upon cooling, the blasting sand was poured from the inside of the coated tube.

Dry formed coatings prepared in the above manner and composed of various percentages of diaspore and bonding glass were much lighter in weight and more porous than the rammed type coatings, but they were weak and friable. Compositions with the higher percentages of bonding glass had greater strength but also exhibited more severe shrinkage cracks than the materials having a less glass content. In areas where the coating was mechanically removed, satisfactory adherence of the coating material to the base metal was observed.

The preparation of this type of coating further indicates the requirement for the development of a more refractory coating bond not subject to firing shrinkage.

Enamel Bonded Porous Insulating Bodies

The possibility was investigated of forming a thick insulating coating from a refractory, prefired, insulating body of high porosity and low weight cemented to the metal structure by a fired glass bond. K30† insulating brick was chosen as the insulating body because of its light weight, low thermal conductivity

and freedom from firing shrinkage at temperatures up to $2,800^{\circ}$ F. or higher. A cone 13 raw matt glaze was used to seal the porous surfaces of the insulating brick. This glaze had the following composition:

Material	Per cent.
Whiting	16.3
Raw Kaolin	4.2
Calcined Kaolin	47.3
Flint	32.4

A ground coat enamel maturing at 135° F. was utilised to cement the glazed insulating body to the base coated metal structure. It was felt that the lower softening point of this bonding glass would reduce the interfacial stress concentrations caused by the differential contraction of the metal and ceramic following the cementing operation.

Using the materials and technique briefly described above, an experimental ceramic lined combustion chamber liner was constructed from a low carbon steel tube $4\frac{1}{2}$ in. in dia. and 12 in. long, using glazed porous tile fashioned with 3 mil of refractory base coat No. 32-22 (see Table 1) using normal coating techniques. Insulating tile pieces 2 in. by $2\frac{1}{2}$ in. were cut from K30 brick and abraded along one face to provide a curved surface which would permit continuous contact with the metal when the tile was mounted in the cylinder. Thirty tile pieces were thus prepared. The cone 13 raw glaze was applied to provide an adherent, continuous surface approximately $\frac{1}{32}$ in. in thickness when fired to $2,300^{\circ}$ F. A dewatered enamel slip containing frit No. 1104M was used as a mortar to cement the glazed tile in place around the interior of the $4\frac{1}{2}$ in. dia. tube. After all moisture had been removed by drying, the combustion tube was placed on end on a stainless steel sheet metal platform and the interior of the tube was filled with blasting sand to prevent movement of the insulating tile. This assembly was charged into an electric furnace at $1,650^{\circ}$ F. and fired for 15 min. During firing the evolution of gases from the enamel caused the tile pieces to separate slightly and thereby reduce the insulating effectiveness of the assembly. Upon cooling, the blasting sand was removed from the centre of the combustion chamber and the enlarged spaces at the tile

*Low temperature enamel ground coat maturing at $1,350^{\circ}$ F. and prepared using frit 1104-M.

† An insulating refractory produced by Babcock and Wilcox Ltd.

joints were patched using raw glaze slip.

Chromel-alumel thermocouples were attached to inner and outer surfaces of the combustion chamber which was then subjected to a gas-air flame test in which no auxiliary air was used to cool the metal surface. Time-temperature curves for inner and outer surfaces are shown in Fig. 6. The test was terminated after a run of 18 min. when hot spots appeared on the metal surface at two points beneath which enlarged tile joints had developed during the preparation of the combustion chamber. A maximum inner surface temperature of 2,350° F. was reached; after 16 min. of operation the outer shell temperature rose rapidly from 750° F. to approximately 1,050° F., at which time hot spots were first observed. When the insulating tiles were mechanically removed good adherence was noted between tile and metal except for those places where overheating of the metal shell occurred.

The application of porous insulating tile to metal through the use of enamel type bonding glasses offers a promising method of substantially reducing the operating temperature of sheet metal structures serving as hot exhaust components. This reduction in temperature further serves to prevent the oxidation of the underlying metal. A decided advantage of this technique of application is the stability of the insulating material which is free from firing shrinkage and which may be bonded by a more refractory bond than the conventional type of insulating top coat.

Further development is required in order to prepare serviceable structural components by this technique. This might entail the design of interlocking tile or the fabrication of monolithic structures, and the improvement of firing methods in order to prevent overheating of the metal shell by heat losses between adjacent tile pieces. The preparation and simulated service test of structural components protected in the above manner is necessary in order to determine the insulating effectiveness, thermal shock resistance, erosion resistance and other properties of the coated member which depend, in a large measure, upon the conditions under which it is to be used.

Summary

Several methods have been investigated for the application of thick insulating coatings to metal. Through the use of graded expansion laminated top coats the maximum thickness of conventional glass bonded insulating coatings has been increased from about 25 mil to over 80 mil for rectangular 2 in. by 4 in. sheet metal specimens. However, difficulty was encountered in applying coatings greater

than 40 mil in thickness on curved specimens. The long heat characteristics of thick, graded expansion coatings completely immersed in a high temperature medium are generally comparable to those of the thinner glass bonded top coats. In these tests coating deterioration, which may be caused by absorption of the base coat into the top coat followed by metal oxidation, takes place more readily at 1,600° F. than at 1,400° F. This phenomenon indicates the feasibility of improving coating durability by lowering metal operating temperatures through the use of thicker coatings of the graded expansion type.

Similar glass bonded crystalline insulating materials prepared by ramming or dry forming in thickness of approximately $\frac{1}{2}$ in. were observed to possess excessive firing shrinkage during hot gas tests. This shrinkage caused wide cracks to form through the entire coating thickness. However, good adherence was obtained for these coatings by the use of bonding glass coating slips between the metal and the insulating coating. Indications are that substantial temperature reductions would be possible by the use of coatings $\frac{1}{2}$ — $\frac{1}{4}$ in. in thickness, although the resultant weight increase would require consideration.

The coating technique involving the attachment to metals of pre-fired thick insulating materials of high porosity offers, perhaps, the greatest promise of meeting the requirements for light weight, insulation and dimensional stability at high temperatures. Further development and refinement of this coating operation is indicated. These steps are required to produce serviceable test components featuring thick insulating components.

1. The preparation of light weight thermal shock resistant bodies.
2. The development of body surface finishes to resist erosion.
3. The study of suitable techniques for bonding materials of low thermal expansion to metals.

A certain weight increase for present structural components would be, of course, a consequence of the use of thick insulating components. However, this weight increase might be offset by the possibility of higher operating temperatures and greater efficiencies or the use of less critical materials of construction. Additional advantages might also be entailed in the wider field of redesign possibilities which might be afforded by the use of thick coatings. Overall weight reduction and simplification of construction might reasonably be expected.

An immediate requirement appears to be the evaluation of these thick insulating coatings in high temperature parts operating under service conditions.

Industrial Electronics

Recent International Convention

MORE than 300 delegates from many parts of the world and representing nine industries met to discuss industrial electronics at a Convention held at Oxford from 8th July to 12th July.

Among the industries represented were the aircraft, motor, rubber, oil, iron and steel, glass and instrument manufacturing, the film industry and electricity supply. Countries sending representatives included the U.S.A., Canada, France, Holland, Australia, India, Pakistan and Eire.

Thirty-eight papers were discussed, all of them dealing with the application of electronics to industry. Among the subjects covered were computers for office and factory, ultrasonics, industrial X-rays, nucleonic instruments, gauge transducers, engine testing and machinery control.

Certain papers presented at the Convention are of some interest to ceramists. A summary of these is given below.

Industrial Applications of X-rays and Sonics

A Method of Ultrasonic Gauging, by F. M. Savage

This paper described a method of measuring wall thickness accurately although only one surface is accessible. A variable frequency oscillator is employed and standing waves are set up between the transducer and the reflecting surface. At the resonant frequency and its harmonics the oscillator anode current increases and the measurement of the frequency interval between these peaks enables the thickness to be calculated.

Improved Techniques in Ultrasonic Flaw Detection—G. Bradfield.

The use of barium titanate crystals with backing and with monitoring crystals to assess the ingoing signal for flaw detection was discussed. The use of laminated wedge mode changers and steerable beam systems of ferro-electric materials were described.

Electronic Sensing Devices

Optical Transducers and Some Industrial Applications, by J. A. Sargrove.

After a brief survey of the principles and characteristics of photocells and electron multipliers, the advantages of various optical arrangements for different applications were considered. Sharp focus

light spot transducers for reflectometers and light scatter transducers for nephelometric determinations were described. Reference to suitable transducers for particle detection in liquids, goniometric applications such as high-speed weighing, line following and edge alignment equipments, was made.

Piezo-Electric Vibration Pick-Ups, by S. Kelly.

The paper dealt with the development and use of displacement pick-ups and accelerometers using Rochelle Salt and barium titanate. By suitable design the units can be produced with constant sensitivity from 1 c/s to better than 20 kc/s, the law being either constant amplitude, constant velocity or constant acceleration. Typical examples are: (a) barium titanate accelerometer—sensitivity 20 mv/g from 5 c/s to 12 kc/s; (b) Rochelle Salt vibration pick-up—equal output voltage 1 c/s to 600 c/s for constant displacement. Details of machining networks to ancillary equipment were given although special amplifier design was not dealt with.

Wire Strain Gauge Transducers for the Measurement of Pressure, Force, Displacement and Acceleration, by J. L. Thompson.

The theory of operation and the construction of resistance wire strain gauges for the measurement of pressure, vibration, acceleration, force and torque were discussed. The special applications of unbonded gauges were considered. Practical details were given of strain gauge technique and special reference was made to methods of fixing gauges to the structures under examination.

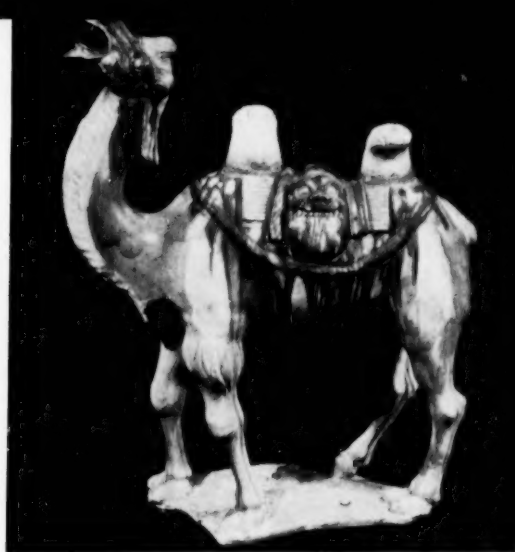
British Titan Products Co. Ltd.—A very well produced and informative booklet on Titanium Oxide in Vitreous Enamels (B.T.P. Publication No. 24) has just been published by British Titan Products. It is hoped to review this booklet in more detail in the near future.

Cadmium Colours.—R. S. Colour Works Ltd. have published a technical leaflet giving the methods of manufacture, general data, tests, and applications of cadmium sulphide; also "liquid bright gold" used in the ceramic industry.

Pottery and Porcelain in Louvre Exhibition

IF proof were needed of the place occupied by pottery and porcelain among the decorative and fine arts, it would be found in the remarkable exhibition of artistic masterpieces which is being held until October in the Pavillon de Marsan of the Louvre Museum in Paris.

Of the 547 exhibits which include all kinds of objets d'art, nearly 150 are of pottery and porcelain. These exhibits have been drawn from a number of countries under the auspices of the International Confederation of Dealers in Works of Art who in co-operation with the Central Union of French Decorative Arts have staged



(C. T. Loo et Cie., Paris)

Chinese Statuette over 1,000 years old

this display of precious masterpieces.

The earliest example of ceramic art is a Greek terra-cotta dating from c. 2400 B.C. in the form of the goddess Chypriot. The majority of pieces exhibited, however, are of comparatively recent times though the exhibition covers a period of well over 4,000 years.

Early Far Eastern work shown includes pieces from the Han epoch, 210 B.C. to A.D. 90, represented by a series of enamelled pots of iris green, and by a horse statuette, and from the T'ang period, A.D. 618 to 906, represented by a camel statuette and a figurine of a woman.

The Chinese porcelains are from the Ming, Kang-Hi, Yung-Tching, and Kien Long periods which flourished between the years A.D. 1386 and 1796. Among these is a Ming squatting figure of the goddess Kouan-Yin in biscuit with the divinity enveloped in a purple enamelled mantle edged with turquoise blue.

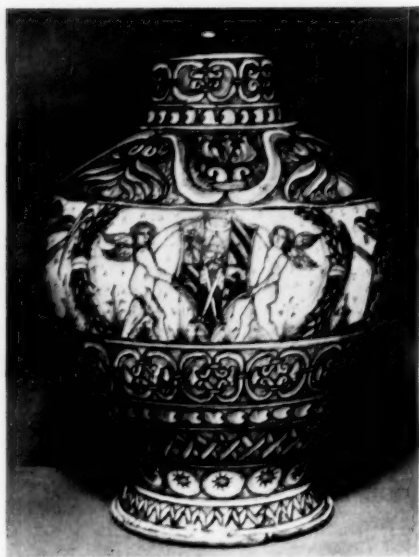
The Middle East is represented by fifteenth-century Damascan and Persian art. One of the most striking pieces in the collection is a large Persian polychrome ball from a mosque in Brousse. The lower half is in undecorated white; the upper half being a fine example of Rhodes decoration with medallions formed of



Terra-cotta of Greek
Goddess from
about 2400 B.C.

(Galerie Segrédakis, Paris)

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LEFT HAND PAGE.

Top left: XVth-century majolica vase from Faenza, Italy (*Brimo de Laroussilhe, Paris*);
 Top right: Black vase from Kang-Hi dynasty, China (*C. T. Loo et Cie., Paris*);
 Centre left: XVth-century Persian polychrome earthenware ball (*Vandermeersch, Paris*);
 Centre right: Sevres porcelain breakfast set made for the Emperor Napoleon I in 1813 (*Altenloh, Brussels*);
 Bottom left: Pair of Dresden statuettes about 15 inches high (*Vandermeersch, Paris*);
 Bottom right: Deep basin from Manises of the Spanish Moor period (*Brimo de Laroussilhe, Paris*)



THIS PAGE.

Top: One of a pair of early XIXth-century vases from Belgium, showing the city hall of Brussels (*Le Brun, Brussels*);
 Centre: Delft plate in Chinese style (*Joseph M. Mopurgo, Amsterdam*);
 Bottom: Pair of XVIIIth-century English candelabra from Chelsea (*Delomosne & Sons, London*)



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LOUVRE EXHIBITION

(Continued from page 219)

branches and leaves falling gracefully from a rosace in the middle of the globe's pole. Inside the cover the flowers are in brilliant shades of green and red. The basic colour of the globe is a rich lapis-lazuli blue. The handle is a twisted thick thong of wool in assorted colours.

The Spanish Moorish period is represented by a stylised floral basin with metallic lights from the "gilded porcelain" work of the fourteenth century from Malaga.

Italian majolica from Florence, Caffagiolo, Faenza, Castel Durante, Deruta and Sienna is exhibited, the oldest piece being from Florence—a mid-fifteenth-century vase with handles. It is decorated with a thick blue-black ornamentation and strokes of manganese violet, with scattered oak leaves and a large heraldic lion on each side.

German pottery and porcelain covers the eighteenth-century "Hausmalerie" work where the artisans decorated the pieces in their own homes, and also the Saxon porcelain of which many specimens were exhibited, including birds of prey beautifully made for King Augustus the Strong.

French pottery exhibits came from most of the important centres of the industry, such as Rouen, Saint-Porchaire, Lille, Strasbourg, Sceaux and Marseilles. French porcelain is repre-

sented by Menecy, Vincennes and, of course, by Sèvres. The latter centre has provided some of the exhibitions most exquisite treasures. The breakfast set ordered by Napoleon for Josephine de Beauharnais is of a rare beauty, and there is also a very fine service made for Catherine II of Russia who ordered it in 1778 for her personal use.

From Belgium come two large vases by M. J. Jacquet which are among the most handsome in the exhibition.

Delft provides five pieces, several with decorations after the "chinoiserie" which had such a vogue in Europe.

Chelsea china, the only representative English exhibit, provided a pair of candelabra dating from about 1765 portraying two couples in hunting costume among a mass of beautifully formed multi-coloured flowers.

The Austrian porcelain from Vienna shows further the Chinese influence.

An entirely different style is that provided by the South American pottery, chiefly from Peru and Mexico, the latter in part from the pre-Columbian period.

The fact that these treasures have been loaned by leading art galleries and antique dealers of the various countries belonging to the International Confederation of Dealers in Works of Art, viz., Austria, Belgium, France, Great Britain, Holland, Italy and the United States, means that all the pieces exhibited are in fact on sale somewhere in the world.

CLAY MINERALS AND THEIR IDENTIFICATION. (Continued from page 206)

shown that anauxite and halloysite which contain more silica and water respectively than pure kaolin have similar X-ray patterns. They are therefore grouped under the kaolinite type of minerals. Nacrite and dickite are placed in the same group.

Similarities in the X-ray patterns have also led to the classification of saponite, beidellite and nontronite with montmorillonite, as the montmorillonite group of clay minerals. The illite group includes clays giving similar patterns to the micas. Further details and a good bibliography on the application of X-rays to ceramics

will be found in an article by H. M. Richardson in "*Ceramics—A Symposium*," published by the British Ceramic Society (Stoke-on-Trent, 1953).

In the limits of a small article it is difficult to do more than present an outline. The subject, moreover, presents such technical difficulties that it is difficult to put down in simple language. It is hoped, however, that this article will indicate to the average ceramist, unskilled in these special techniques, the outline of the methods employed to distinguish and classify the clay minerals. Those requiring fuller information are recommended to study the works quoted in the text.

Production Exhibition—1954

A New Venture

A NEW and highly successful exhibition designed to encourage and show means of improving productivity was held at the National Hall, Olympia, from 7th July to 14th July. The exhibition was sponsored by the Institution of Production Engineers, and was held under the patronage of H.R.H. the Duke of Edinburgh.

In the catalogue, an article explaining the purpose of the exhibition says well that sheer physical effort can disguise low productivity, and achieve a high level of production; lavish use of power will do the same; inventive genius can create products so unique that the efficiency of the processes which produce them becomes comparatively unimportant; high productivity relates to the skill and imagination with which these elements are used to get the maximum production from the available resources. Its importance grows as power, machinery, and technology become commonplace amongst the nations of the world, and our comparative standard of living depends increasingly on the skill with which they are used.

The basis of productivity, as of production, is research. Beginning with the exhibit of the Department of Scientific and Industrial Research on the central avenue, the exhibition aims to tell a graphic story of the research and development which stands behind British industry; how by closer co-operation, closer understanding between researchers and those responsible for production, greater results can be achieved; how the time lag between discovery and production can be reduced; how research can be used to bring new economy to established processes. It is supported by a range of research institutions in a wide field of industries.

Wider understanding, and wholesale adoption, of the principles of standardisation could by itself lift British industry to a quite new level of productivity overnight. Correctly applied

they do not impose uniformity on the individual, but are a sure road to lower costs and higher productivity. The British Standards Institution exhibit showed the application of these principles to a wide variety of industries.

One side of the hall demonstrated the human element in productivity and to methods and processes which contribute to higher productivity, production engineering, work study, industrial finishing, precision casting, instrumentation, weighing and measuring equipment, induction heating, scientific instruments, industrial refrigeration, etc. The range was wide, but they all had one characteristic in common; their contribution was not only to an improved quality of product, but to greater efficiency in the production process. On the other side of the hall were services—electrical development, production control, lubrication, high-speed cinematography, X-ray examination of metals, developments in metals and materials, stands showing the correct use of lighting and colour, and part of a complete production line showing contrast between old and new aids to production. Timely information is the lifeblood of rising productivity, and the resources of the trade and technical press were displayed.

Among the stands the following were of particular interest.

Ministry of Fuel and Power, Thames House South, Millbank, London, S.W.1
Tel.: ABBey 7000.

The Ministry of Fuel and Power exhibited means developed in recent years to improve the fuel efficiency in industry.

In the promotion of fuel efficiency the Ministry until recently, among other services, provided direct technical advice to the industrialist initially by means of individual visits from experienced fuel engineers but increasingly by the use, in the factory

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involved, of a wide range of metering and recording instruments. Operated by a team of engineers this instrumentation provides detailed information capable of yielding on analysis a complete heat and power balance for the whole factory. Such surveys have given valuable results in revealing immediate possibilities of increasing economy and efficiency which are generally associated with higher productivity. They also provide basic information for forward long-term planning. The necessary equipment—flow meters, multi-point recorders, gauges, special fittings of one kind and another—have, to secure mobility, been housed and transported in suitably adapted and fitted vans, one of which with all its contents will be on exhibition. This service to industry, among others, has now been taken over from the Ministry by the newly constituted National Industrial Fuel Efficiency Service, which aims to continue and expand this work.

Sondes Place Research Institute, (Mactaggart & Evans Ltd.), Dorking, Surrey. Tel.: Dorking 3265/6.

Sondes Place Research Institute, Dorking, is a consultant organisation which undertakes industrial research and development on behalf of individual firms in a very wide range of industries.

The Institute, as it now stands, is composed of fifteen separate laboratories besides stores, offices, dark room, drawing office, library, semi-scale plant buildings with 2,500 sq. ft. of floor space, and engineering workshops with about half that area. The laboratories can broadly be divided into two classes. Firstly, there are the research and development departments, such as the Main Chemical Laboratory and the Physical, Constant Temperature, High Temperature and Bench Scale Laboratories. Secondly, there are the service departments, such as the Analytical Laboratory and the Physical Testing and Cement Test Laboratories, which carry out analysis and testing for the rest of the organisation. The Dark Room, the X-ray Analysis Laboratory, the Drawing Office and the Plant Buildings and Workshops act both as service and research departments. In the last three, for example, the Institute not only

designs and manufactures much of its own apparatus, but also constructs semi- and full-scale prototype plant and machinery for its clients. The Information Service, in conjunction with the Library, supplies the bibliographical needs of the Institute's staff and also conducts market surveys and a postal technical abstracting service for clients.

Remington Rand Ltd., Commonwealth House, 1-19 New Oxford Street, London, W.C.1. Tel.: CHAncery 8888.

Industrial evolution becomes increasingly dependent upon efficient techniques of production control. Remington Rand, recognising the urgency of production problems, have provided without fee or obligation, an unrivalled systems advisory service, backed by a comprehensive range of equipment specifically designed as production aids. These include: "Kardex," which brings order and control to production, from design to final assembly; "Graphdex," charts and planners which control the movement of material in production and express visually the immediate and forward load on machines; "Sched-U-Graph," which is extensively used for machine loading, but has far wider applications.

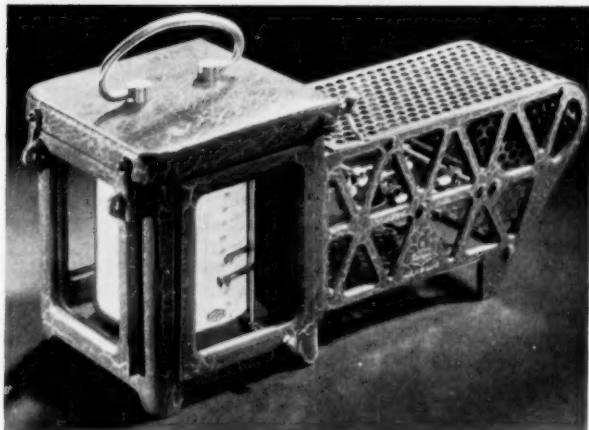
Scientific Instrument Manufacturers' Association of Great Britain Ltd. 20 Queen Anne Street, London, W.1. Tel.: LAngham 4251/2.

Among the member firms of the Association exhibiting instruments for increasing production and improving the efficiency of factory operation was C. F. Casella & Co. Ltd., London, W.1, who showed instruments for indicating and recording air temperature, humidity, dew point and frost point, as well as air flow and pressure.

Institution of Personnel Management, Management House, 8 Hill Street, London, W.1. Tel.: GROsvenor 6000.

This exhibit illustrated personnel management's contribution to better industrial relations and thus to increased productivity. Productivity depends upon the collective contribution of all grades of workers, and personnel management aims at the best and fullest use of their capacities, which

Casella Thermo-Hygrograph, for making continuous records of temperature and humidity. A bi-metallic strip reacts to temperature changes; a specially prepared bundle of human hair to changes in humidity



can only be achieved if their well-being and co-operation at work is ensured.

The exhibit also described some of the Institute of Personnel Management's activities through which it seeks to achieve its aim of furthering the development of personnel management, such as information services, training courses, meetings, conferences and publications.

Fisher & Ludlow Ltd., Bordesley Works, Birmingham 12. Tel.: Victoria 2371.

The aim of the stand was to give a general picture of the various methods of material handling as a means to increased productivity.

The Pallet Selection Chart showed ten basic pallet types plotted against eight Material Groups, so that it was possible to see at a glance the correct type of pallet for the selected material, or, conversely, which groups of materials can be handled on the selected type of pallet.

The "Flowstack" Pallet Manual can be obtained from the manufacturers.

The "Flowlink" unit-construction overhead chain conveyor with pressed steel track, all bends, both horizontal and vertical, press made and interchangeable and the "Flowline" unit-construction belt conveyor system for transporting, processing, assembling and packing with standard range belt widths 12 in., 18 in., 24 in. and 30 in. and capacities up to 6,000 lb. load per conveyor were also exhibited.

The British Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel.: TEMple Bar 9434.

The theme of the Association's stand was the vital part played by electricity in the field of industrial engineering. Industrial engineering is a subject which is ever growing in importance, and whereas all branches cannot be displayed, some more important fields for the study are illustrated.

Production design was demonstrated by a product which has been redesigned because of the application of a new process, such as high frequency induction heating. The effect of this change of design has repercussions on plant layout and the human factors.

Industrial lighting is a field which always well repays study; a light meter, lamps, and photographs of good installations were shown.

Holland & Hannen and Cubitts Ltd., Psychromatics Section, 258 Gray's Inn Road, London, W.C.1. Tel.: TERMINUS 3388.

Head office: 1 Queen Anne's Gate, London, S.W.1.

The more scientific approach to the lighting and decoration of factory interiors and equipment in the interests of higher occupational efficiency was the subject of this exhibit. Under the registered name of Psychromatics the Cubitt organisation operates a specialist service for the design and

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installation of complete schemes embodying the most up-to-date technique.

The exhibit, in the form of a pictorial display, illustrated the principles involved and the benefits to be derived from good lighting and colour treatment and included some recent examples of successful installations carried out by the Company.

Details given of the Cubitt production facilities stressed the economical nature of these schemes and showed that by efficient organisation existing factories may be equipped without inconvenience to the current production programme.

The Murchie Trading Co. Ltd.,
*Airsonic Division, 11 Kings Road,
Sloane Square, London, S.W.3. Tel.:
SLOane 9610.*

The "Airsonic" Industrial Stethoscope is a valuable aid to fault detection. It materially reduces production costs. Rejects in manufacture are kept down to the minimum and plant breakdown avoided.

The location of faults by sound is recognised today as a simple, certain technique. Metal objects, mechanical parts, fluids and gases, whether moving or stationary, produce or react to sound in their own characteristic way. Stresses, fissures, unsound joints or excessive wear set up variations in these characteristic sounds. To listen to these variations, amplify them and interpret them, the "Airsonic" Industrial Stethoscope was designed. It has no diaphragm, and is non-electric. Thus, having no fixed frequency of its own, it is capable of receiving sounds at any pitch, and reproducing them at uniform strength.

Institution of Production Engineers,
*10 Chesterfield Street, London, W.1.
Tel.: GROsvenor 5254/9.*

The Institute of Production Engineers was founded in 1921 as a result of the great demand for increased production during the first world war. Its present membership is almost 10,000 strong, with branches established in all the main industrial centres of Great Britain, and in Australia, Canada, India, New Zealand and South Africa. The aim of the founder members was to provide a means of studying the complex prob-

lems of industrial production, and for the exchange of ideas on productivity in general.

The Institution holds many lecture meetings and conferences in various parts of the country during the year. The Institution Journal, published monthly, records outstanding papers presented and offers a valuable medium for the dissemination of the current views and technological knowledge of leading industrialists.

The Institution offers two Schofield Travel Scholarships each year to graduates which allow a six-month study tour abroad. There are also various other awards.

The Hazelton Memorial Library constitutes a most valuable technical library and information service, keeping members fully up-to-date with the latest developments in industrial problems.

At the exhibition the Institution illustrated its many aspects and functions and provided an information service to the exhibition in general.

Bakelite Ltd., 12-18 Grosvenor Gardens, London, S.W.1. Tel.: SLOane 0898.

"Bakelite" resins are used for a wide range of bonding operations—woodworking, lamp-capping, grinding-wheel manufacture, etc.—because of their uniformity, adhesive strength and rapid-setting characteristics. Special grades are now produced for the revolutionary shell method of making foundry moulds and cores, and another interesting group comprises polyester resins which, reinforced with glass fibres, offer a new material of great strength for the easy fabrication of press-tools, car bodies and housings of all kinds.

Rubery, Owen & Co. Ltd., Darlaston. Tel.: Darlaston 130.

Conveyancer Fork Trucks Ltd., Warrington. Tel.: Warrington 2244.

Exhibits included a range of metal pallets produced by Rubery, Owen & Co. Ltd., and a battery electric "Conveyancer" fork truck produced by Conveyancer Fork Trucks Ltd. Both companies are members of the Owen Organisation.

The use of fork trucks and pallets has been developed in British industry very widely since 1945 and the con-

tribution to increased productivity which these methods of handling have brought about is outstanding. There is hardly a branch of industry which could not benefit from a study of its materials handling methods, and it is in materials handling method improvement that the greatest potential economies are generally to be found.

During the exhibition the stand was manned by materials handling experts from the two exhibiting companies. Both companies would be pleased to arrange a survey of the materials handling methods of any interested company at some future early date.

R. H. Corbett & Co. Ltd., Hydrum Works, Burgess Hill, Sussex. Tel.: Burgess Hill 3333.

R. H. Corbett & Co. Ltd. showed equipment which contributes to increased production. This included the well-known "Hydruped" fork lift truck, the "Hydrum LP" loader, the "Hydrum STP" stacker, and the new "Hybarrow" which is an entirely new machine with foot-operated hydraulic lift for transporting and lifting on the "sack barrow" principle. It is strong and light and has a capacity of 500 lb. to a height of 54 in. and the price is extremely modest.

Also new was the "Hydrum Hy-stacker." This machine has been specially designed for stores of considerable height where it is desired to keep the passages as narrow as possible. The operator travels up with the load, which he transfers to shelves

at the appropriate level. The machine is operated by traction battery or by mains electricity as desired, and it can work in aisle width of 2 ft.

Ministry of Labour and National Service, 8 St. James's Square, London, S.W.1. Tel.: WHITEhall 6200.

The services provided by the Ministry of Labour and National Service illustrated "The Human Factor in Productivity."

Section I—"Opportunity to Work" dealt with the problems of the disabled; other adults in need of training; older men and women; ex-Regulars; redundancy and transfer.

Section II—"Making the Best use of Manpower" dealt with the Ministry's Vocational Guidance and Careers and Placing Services; Training Within Industry (T.W.I.); and Apprenticeship Training and Personnel Selection.

Section III—"Avoiding Wastage of Manpower" dealt with safety, health and welfare of workers and the service provided by the Ministry's Factory Inspectorate.

Section IV—"Aiming at Good Team Work" dealt with good personnel management, joint consultation and the Ministry's Personnel Management Advisory Service; communications in industry.

There was also a stand with a display showing the Service provided by Education Authorities and the Ministry of Labour and National Service for assisting boys and girls to find the jobs best suited to them.



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Gas in the Ceramic Industry

THERE was a departure from the usual procedure on one of the mornings at the annual general meeting of the Institution of Gas Engineers when instead of the usual paper being read the conference embarked at once on a discussion. The subject was the use of gas as an industrial fuel. In the course of the discussion Mr. A. Dinsdale presented the following contribution by Dr. A. T. Green, C.B.E. (Director of Research, The British Ceramic Research Association) who was unfortunately unable to attend the conference because of illness:

The ceramic industry includes a wide variety of activities which can conveniently be classified under the three main headings of pottery, refractories and heavy clay. Of these, only pottery is concerned to any large degree with the use of town gas, and its principal use is for the firing of tunnel kilns.

The progressive introduction of tunnel kiln firing during the last twenty years has brought about a revolution in the manufacturing process. It has shifted the emphasis from intermittent processes to continuous ones, it has enabled more efficient use to be made of both fuel and labour, and it has reduced substantially the burning of raw coal and the atmospheric pollution that goes with it.

It was quite plain from the beginning that town gas, because of certain of its characteristic properties, was likely to take a prominent part in this development, and so it has proved. Cleanliness, particularly with regard to freedom from excessive sulphur content, constancy of quality and ease of control are points which come easily to mind. The extent to which the fuel has established itself may be seen from the growth of the number of tunnel kilns using it. The first town-gas tunnel kiln to be built in Stoke-on-Trent was installed in 1932. The number increased steadily until the outbreak of the war, and still more rapidly after the war ended. In 1938 there were sixty-six, in 1949 there were 150, and the present number is about 190.

It is, of course, possible to fire tunnel kilns on other fuels, such as electricity, producer gas or oil. One of the factors which play a leading part in the choice of fuel is the cost. Although a considerable amount of information is available, no hard and fast conclusions

can be drawn on this issue. For instance, although electricity costs about three times as much per therm as town gas costs, there is some compensation in the high efficiency of utilisation at the kiln as a result of the elimination of the use of protective saggars for the ware and the reduced flue gas losses. The efficiencies of kilns vary over such a wide range, however, that it is not possible to come to any general conclusion on the question whether this compensation is adequate or not. It is probable that, when capital costs and maintenance have been taken into account, gas is the cheaper of the two, and certainly much more gas is used than electricity. On this issue it is of some significance to note that the temperature of firing seems to be a very important factor in determining the field in which either one or the other predominates. In the firing of decorated ware, where the temperature is in the range of 700°-800° C., electricity is much more commonly used than gas. In the firing of biscuit ware, from 1,100°-1,200° C., most kilns use gas, although it must be noted that recently a china biscuit kiln has been successfully operated on electricity at a temperature over 1,200° C. In glaze firing, from 1,000°-1,100° C., both fuels find frequent use. It seems, then, that it is in the high temperature ranges that town gas finds its most favourable environment.

So far we have dealt only with the present situation, and it would probably be more profitable and more in accord with the purpose of this discussion to suggest one or two ways in which the use of town gas in pottery firing might be furthered. Three main points seem to suggest themselves.

(a) It always seems to me that more attention is given to insulation in electric kilns than in gas kilns, presumably because of the higher cost per therm. Although it is easier, because of certain features of design, to insulate electric kilns effectively, there seems to be a case for improving the competitive position of gas by obtaining the maximum economic conservation of heat in the kiln.

(b) The question of the firing of pottery in an open flame type of kiln without the use of saggars is of vital economic significance. It can be achieved, it increases the efficiency of use of the fuel by a very substantial amount, either by eliminating

the use of the muffle kiln or by increasing the amount of ware in the setting in the open flame kiln. Certain problems still remain to be solved in this connection. In biscuit firing, the effect of the atmosphere on the colour of the goods and the effect of exposure to hot or cold air currents on distortion are two instances where further understanding is desirable.

A recent interesting development is "semi-open" firing, namely, the use of a protective structure around the whole of the setting on one car, to replace the individual saggars.

In glost firing, there is the problem of maintaining the balance between the vapour pressure of certain constituents in the glaze and that of the same constituents in the atmosphere. Too much disturbance of the atmosphere can cause a deterioration in the quality of the glaze surface. In glost firing, too, the influence of sulphur on the glaze surface can give rise to faulty products.

(c) Much more knowledge is required on the most efficient method of combus-

tion and heat transfer. The distribution of heat throughout the setting, the part played by radiation and convection, the optimum use of pre-heated air, and the principles of gas flow in the kiln, are all worthy of investigation. For example, it is interesting to note that kilns have recently been built in which the gas is fed to the kilns through a large number of small jets at high pressure and without primary air. The neat gas is thus projected into the space around and between the goods, mixes with the warm air flowing down the kiln from the exit end and burns without visible flame.

The position of town gas as a major fuel in the firing of pottery is established and assured. It is suggested, however, that there is still scope for investigation and improvement, in order that still better practice may be developed, and it is hoped that this contribution to the discussion may stimulate both thought and action not only along the lines suggested but also along others which may well occur to you.

CHINESE PORCELAIN EXPORTS

THE thousand-year-old porcelain factories of Ching Te Chen, Kiangsi Province, China, are again exporting to this country.

When war broke out in 1939 the importation of coarse porcelain from China was suspended. Since then there has been little information about these ancient factories, and whether in fact they had survived. It is now clear that pottery is still being made at this, the greatest of the Chinese workshops.

Starting production early in the Sung

Dynasty (A.D. 960-1278), the Ching Te Chen factory gradually developed to the ranking status of the provider of porcelain for the Imperial Palace. Today it produces porcelain ware both for utility purposes such as cups and saucers, bowls, etc., and ornaments such as celadon ducks and cockerels. These animals, much smaller than current English ones, are modelled on the breeds in vogue during the early part of the Ching Dynasty (1644-1901). They are very life-like and make handsome ornaments.

Examples of the porcelain from the factories of Ching Te Chen which are now obtainable once more in this country



The British Ceramic Society

WE give below abstracts of the three papers appearing in the *Transactions* of the British Ceramic Society for June, 1954.

A Study of the Monoclinic Tetragonal Phase Transformation in Zirconia, by P. Murray and E. B. Allison.

The kinetics of the monoclinic to tetragonal phase transformation in zirconia have been studied using the change in specific gravity as an index of the amount transformed. The isothermal transformation proceeds according to the equation:

$$\frac{dP}{dt} = K \left(\frac{100-P}{100} \right)^{2.5}$$

where $\frac{dP}{dt}$ = rate of transformation

and P = amount of monoclinic phase transformed both at time t .

Application of the Arrhenius relation gives a value for the activation energy of 80,600 cal/mole of tetragonal phase formed.

The course of the transformation for constant heating-rate conditions has been predicted by integration of the kinetic constants. From this, two important features of differential thermal analysis methods follow.

- (1) Heating rate has a marked effect on the peak temperature obtained.
- (2) The amount of transformation at the peak is only of the order of 40 to 60 per cent. Consequently the transformation is still proceeding even after the peak has been passed, and hence the return of the thermal analysis curve to the base line does not depend entirely on thermal diffusivity.

The transformation has also been studied under constant heating-rate conditions by means of differential thermal analysis and also by a dilatometric method. The results from these alternative approaches compare favourably with those predicted from the kinetic work.

The reverse change obtained on cooling the tetragonal phase has been followed. This transformation occurs in a much lower temperature range (950°—850° C.) than the forward transformation (1,100°—1,190° C.).

The tetragonal \rightarrow monoclinic transition is affected to a considerable extent by high-temperature annealing and also by thermal cycling. It is suggested that this

effect is connected with the state of order in the tetragonal lattice.

The Geology of Fireclays, by P. S. Keeling.

The British Coal Measures, together with those of North France, Belgium, Westphalia and the Don Basin, were laid down in a subsidising basin bounded on the north by a large continental mass occupying the North Atlantic region, and on the south by a mobile belt of rising mountain-chains stretching roughly east and west through north-central France.

The sequence of strata shows a rhythmic character, the following cycle, with many variations, occurring over and over again. (1) Marine shale, (6) Coal, (5) Seat-earth, usually a fireclay, (4) Shale/mudstone, (3) Grit, gritty shale, sandstone, (2) Mudstone and shale, (1) Marine shale.

The fireclays occupy a certain definite position in this cycle. They were deposited in the delta swamps prior to complete silting up, and are the finest-grained of all the Coal Measure sediments. They were the soils on which grew the prolific Coal Measure vegetation.

They owe their refractoriness to an absence of fluxes, which may be due partly to the conditions under which they were laid down and partly to the extraction of potash and other compounds by the Coal Measure vegetation.

The Preparation and Properties of Vanadium Spinel, by H. M. Richardson, F. Ball and G. R. Rigby.

Four vanadium spinels—ferrous, magnesium, manganese and zinc vanadites—have been prepared, and all have been found to possess the normal or α -spinel structure. It was found that ferrous oxide could enter into solid solution with certain of these vanadites, but that this solution was not accompanied by any overall growth of the specimen. Magnetite entered into solid solution with the vanadites at 1,000° C., and small growths or bursting expansions were observed. Ferrous and magnesium chromites entered into solution less readily than magnetite, and a single phase was not formed at temperatures below 1,300° C., although small growths or bursting expansions were observed and were at a maximum after being heated to 1,200° C. The rate of solid solution between the vanadites and aluminous spinels was

very sluggish and not complete at 1,300° C., and no growth effects were observed. X-ray photographs indicated that the various spinels diffused into one another

at different rates, for example the vanadates diffused more rapidly into the chromites and aluminates than they diffused into the vanadate lattice.

American Technical Digest

Copies of the original articles to which these summaries relate can usually be obtained from the Science Museum Library or from the American Library, American Embassy, 1 Grosvenor Square, London, S.W.1.

Improved Fireclay Products

The job of filling fireclay moulds may be simplified and improved by using a pneumatic table device which completely fills all the areas of the hand-filled mould and produces a better product. Refractory shapes weighing up to 300 lb., which normally require the exertions of at least two men in the bumping operation needed to completely fill-out such moulds, are bumped mechanically by this method at the Denver Fire Clay Company, Denver, Colorado.

Using this unit, one man depresses the foot pedal which actuates the table to bump clay-filled moulds up to 4 ft. by 4 ft. in size, completely filling the mould and making a more dense product. This method releases some man-power for other more important jobs in the mill.

How the Pneumatic Table Works

The unit utilises a pneumatic cylinder with a 7-in. stroke, which is slow in the rising cycle and rapid in descent, as the basis for the pumping action. A horizontal 3 ft. by 3 ft. steel table is connected to this cylinder, carrying the moulds upward, then quickly dropping away from them. The cylinder's stroke is adjustable for different heights, but normally the setting remains unchanged.

Frequently the bumping table is used on shapes that are rammed by an air-hammer. Such units are generally rammed first, and then bumped—a combination which assures good density in every portion of the most complicated shape.

Brick and Clay Record, December, 1953, page 73.

Improved Drying Equipment and Techniques

Good drying techniques for the production of whiteware depend upon the proper application of air flow, air conditioning and air control; and drying equipment and techniques must be chosen according to the differences in (1) body material used; (2) body reaction to temperature change; (3) humidity; (4) shape of ware; and (5) plant operation. Also, a good drying system should be

chosen which gives the greatest improvement for the least capital investment and the lowest possible operating cost. The following examples are cited:

Sanitary Ware Plants

A mould drying installation in the W. A. Case & Sons' pottery, Robinson, Illinois, permitted an increase in production to two casts per 12 hours from a normal of one cast per mould per eight-hour day without any difficulty. The casting shop was approximately 600 ft. long and 105 ft. to 120 ft. wide, with casting benches on each side of the centre aisle. An overhead duct system was designed to distribute air throughout the room. The main heater houses were placed outside the building along with the concrete block return ducts which draw the air from the room through holes in the wall. The return ducts feed the air to the heater house, where two large gas-fired heaters bring it back to the desired temperature level. The air is then drawn through a large double inlet fan and blown out through the main header and distribution ducts to the casting shop. Ducts are placed strategically throughout the room to deliver the air at floor level under the casting benches and to apply the proper drying rates to the moulds. Streamlined fittings in the duct system allow the air to be distributed throughout approximately 175 ft. without any appreciable pressure drop.

No automatic controls, other than those on the heaters, are used. However, by adjusting the thermostats connected to the heater, it is possible to maintain the desired temperature throughout the entire casting shop to within 3 degrees.

This particular problem worked out to be not just a heating installation but actually a batch-type dryer where it was necessary to accurately calculate the water quantities that would be left inside the moulds, and also water that would be dissipated by the ware prior to its removal from the casting shop. The volume of air required to supply the heat necessary to remove the water

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load in a given period of time was determined. It was then only necessary to design duct and air handling systems to deliver the predetermined heat quantities to the desired points evenly and without creating excessive draught.

Electrical Porcelain

Three small batch type drying units were installed at the Square-D Company, Peru, Indiana, to replace the old method of using a large room with racks for drying low-tension electrical porcelain. Direct-fired gas heaters were used to maintain the proper temperature level demanded by the control instruments in the drying chamber. Air was circulated by a fan and duct system—being removed from the dryer through a longitudinal centre duct inside the chamber, delivered to the heaters and raised to proper temperature, taken through the fan, and blown back down through very thin slotted longitudinal ducts along each side of the dryer. The air is reflected off the floor in a circular motion up through the pallets. Fresh air is admitted through automatically-controlled dampers. Moisture-laden air is removed from the drying chamber when necessary by two balanced dampers on each side of the fan, through the bustle pipes and to an exit in the roof.

Instrumentation for the above functions included a cam type pneumatic

instrument for controlling wet and dry bulb temperatures—the wet bulb side controlling the admission and escape of air from the chamber, and the dry bulb side controlling the gas burners in the furnace. An independent high-temperature cut-off control was used on the furnace. The new system shortened the drying cycle from 12 to 36 hours to about 7 hours for average type ware and 8 hours for heavy ware. Heat consumption was cut in half.

Jet Drying

The following is an example of an installation designed for mould release drying of 6 in. by 10 in. suspension type electrical insulators: The ware is taken from the hot press and placed on a conveyor which runs underneath a jet header. The jets are approximately 2½ in. above the face of the ware. The drying tunnel is about 6 ft. wide and 50 ft. long, and the drying time for these particular insulators is about 28 to 30 minutes. After the ware and moulds pass through the dryer, they are manually removed from the conveyor and the ware turned out and placed on pallets. The moulds are then placed in a small conveyor type dryer about 3 ft. wide and 50 ft. long, which returns them to the press. During this 15-minute period the mould is dried internally and is ready for repress when it arrives at the other end of the dryer.

Air is circulated in the dryers by large fans located above the conveyor. All portions below the conveyor faces are connected in such a way as to become a large return air plenum chamber. Air is drawn from this chamber up through side ducts and then to the fan inlet. To maintain the necessary temperature level (about 120° F.), a portion of the return air is passed through a gas-fired heater. Small quantities of the air are then mixed with the return air coming up through the ducts.

A temperature controller governs the output of the heater and manually-operated dampers feed the return air ducts with warm air from the heater. After this unit is once started and adjusted in the morning, the air temperature will remain constant throughout the day. A small damper was placed on top of the return air header to admit exterior air as necessary. However, the leakage around the various portions of the conveyor seems to compensate for the moisture picked up from the ware.

The new installation required less moulds and mould stacking and increased production to approximately six pieces per minute.

Ceramic Bulletin, November, 1953, page 373.

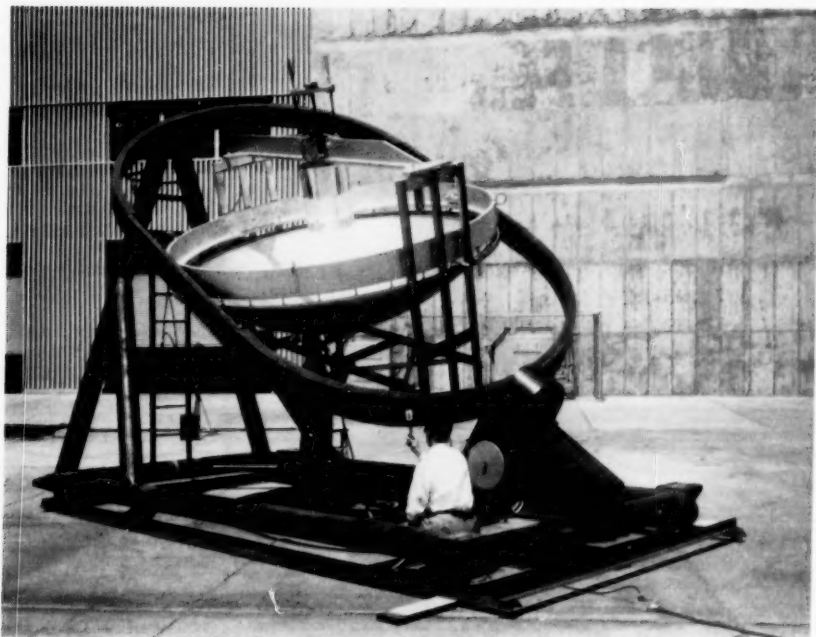
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The 120-in. solar furnace showing the large aluminium mirror which collects the sun's rays

Convair's New Solar Furnace

by

THOMAS A. DICKINSON

THE largest solar furnace in the United States is now being used by Consolidated Vultee Aircraft Corporation's San Diego (California) division for research work with metal and ceramic materials.

Basic part of the instrument is a 120-in. diameter polished aluminium mirror which serves as a parabolic reflector. Made of $\frac{1}{4}$ -in. plate stock, this reflector draws its power from a 10,000° F. heat source—the sun.

Rays from the sun are reflected to a $\frac{1}{8}$ -in. diameter focal point, which is 34 in. from the centre of the mirror. Test specimens at the focal point are retained by metal jaws.

When sky conditions are ideal the furnace can develop a temperature of 8,500° F. at the focal point. This is

approximately 85 per cent. of the temperature of the sun's surface. (The temperature produced by an oxy-acetylene torch, by comparison, is around 5,800° F.)

The heat output of the solar furnace in an oxidizing atmosphere is exceptionally pure. There is no interference from electric or magnetic fields or gases, as in more conventional furnaces, and test specimens with the highest melting temperatures can be melted and solidified in a matter of seconds.

A bridge structure, spanning the mirror a short distance beyond the focal spot, supports the specimen holder; and, after part of a sample melts, adjacent regions are moved into the focal spot by means of a



With asbestos gloves, an engineer removes a ceramic specimen after the sun has burnt a deep hole in it

motor-driven screw.

The bridge also supports a cylindrical barrel which is about 18 in. in diameter. This is used to shade a part of the mirror from the specimen so that the amount of solar radiation concentrated on a specimen can be controlled.

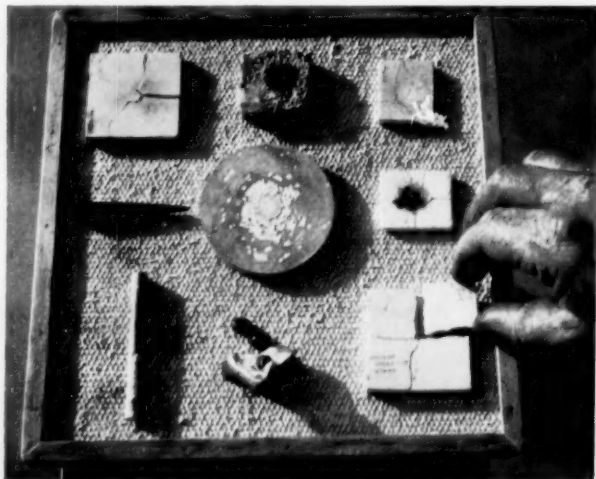
The mirror has a central opening 22 in. in diameter which enables observers to see the focal spot area from a position on the ground behind the mirror. A telescope mounted

near the opening permits the viewing of heating or melting details.

In order to keep the focal spot in one location on the specimen, the mirror is mounted in a gimbal ring which aligns the polar axis of the mounting parallel to the axis of the earth. An accurate clock mechanism, driven by a synchronous motor, coordinates movement of the mirror with that of the sun, so that the furnace can be used for extended periods of time.

A selection of ceramic materials tested in Convair's solar furnace is shown below

Top row: Fused aluminium oxide, melting point 2,030° C.; firebrick, melting point 1,650° C.; zirconium dioxide, melting point 2,700° C. Centre row: Graphite, melting point 3,500° C.; boron nitride, melting point 3,000° C.; pressed aluminium oxide, melting point 2,030° C. Bottom row: Boron nitride melting point 3,000° C.; aluminium magnesium silicate, melting point 1,650° C.; magnesium oxide, melting point 2,800° C.



South African News

Better Plant and Equipment Wanted

At the annual general meeting of the Potters Association, held recently, a plea was made for more permits to import better plant and equipment, so that the industry would be in a position to compete on equal terms with overseas potters when freer trade conditions return.

The industry was making the fullest use of the raw material permits it receives. At present more than three-quarters of the industry's output consisted of articles essential to the country.

Decrease in Vereeniging Brick Earnings

The annual report of the Vereeniging Brick & Tile Company for 1953 shows a consolidated net profit of £298,876, against £306,459 for 1952.

Regarding the subsidiary companies, Vereeniging Tiles had a satisfactory year, but production of Rhodesian Refractories was "severely hindered" by exceptional rains, labour shortages and power breakdowns, the directors report.

Glass Fibre Products

A private company for the manufacture of glass fibres and glass fibre products in the Union of South Africa has been registered under the name of Fibreglass South Africa (Pty) Ltd., with an initial capital of £100,000. The shareholders are Plate Glass & Shatterprufe Industries Ltd., of South Africa, and Fibreglass Ltd., of St. Helens, England, a subsidiary of Pilkington Brothers Ltd., of St. Helens. A manufacturing plant will be erected at Springs, Transvaal, and building operations will commence immediately. It is expected that the factory will be in production during the latter half of 1954.

Clay Research in South Africa

A recent example from the National Chemical Research Laboratory illustrates how an investigation undertaken with one end in view leads to applications in quite a different field. In the course of mining operations to produce coal for the Union's oil-from-coal project, a dull-black brittle material was encountered and gave much trouble from crumbling walls and pillars. Samples were sent to the National Chemical Research Laboratory for identification, with a request for advice on how to prevent its crumbling on exposure. On examination the material proved to be a high-grade flint clay. This clay is much in demand by

the ceramic industries for the making of refractory bricks for lining furnaces working at high temperatures.

Owen Falls Scheme Uses 30,000 ft. of British Glass

Thirty thousand feet of British-made glass has gone into the construction of the Uganda Electricity Board's new hydro-electric scheme at Owen Falls.

The glass was manufactured and shipped by Pilkington Brothers Ltd., of St. Helens, Lancashire. The bulk of the order was for Georgian wired polished glass, sheet glass and polished plate glass. Smaller quantities of hollow glass blocks and tinted patterned and mirror glass have also been supplied.

Armourlight toughened glass insulators have been extensively used in overhead transmission lines. The first 132 kilovolt line, now under erection in two sections from Owen Falls to Kampala and from Owen Falls to Tororo, covering 120 miles, has also been equipped with these toughened glass insulators.

Modern Laboratory for Brick and Tile Works

What is considered to be the most modern laboratory of its kind in the Southern Hemisphere was recently opened at the works of the Vereeniging Brick & Tile Co. Ltd., by Mr. T. W. Coulter, chairman of the company.

The laboratory is equipped with a complete pilot plant. In the furnace room the twenty-five electrically-fired furnaces are automatically controlled and can attain temperatures of up to 1,800° C. The laboratory includes an X-ray department and a physico-chemical department.

Personal

Mr. M. Lubner has been elected chairman of the South African National Flat Glass Association, and Mr. H. Taylor vice-chairman.

New Tile Factory

Johnson Tiles (Pty) Ltd., Olifantsfontein and Pretoria, in association with the local representatives of H. & R. Johnson, T. L. Elliott & Co., erected a pilot plant in 1948, and in 1949 small scale manufacturing was started. In this plant a tile 6 in. by 3 in. was made, but in 1951 it was possible to put into production a full range of the 6 in. by 6 in. tiles, with the essential fittings. The local company is now operating in a new factory on a 30-acre site, the factory covering about

CERAMICS

an acre and a half in a one-storey building. The production of the glazed wall tiles has been planned on the uninterrupted flow basis.

The modern plant installed in the factory includes fully automatic tile pressers and various semi-automatic machines. The two-passing kilns are electrically operated. Supervision has been under ceramic experts from England. The pilot plant was started by the general manager, Mr. L. H. D. Sherman, who was previously with the parent firm in England.

His six years' work in South Africa has given him an intimate knowledge of local clays and materials and the best ways in which to handle them. The new factory has been planned to make a complete range of 6 in. tiles, 6 in. by 3 in. capping tiles in bright enamels, matt, dull or eggshell and mottles, providing a total range of eighteen hues. Since work was concentrated in the new factory, production has been done on mass-production basis, and in addition to the various pastel shade items white tiles are being made. There has been a big sale of "5283 Theatre Green" type for hospital operating theatres and sterilising rooms. The plant is designed to allow for ready increase in the production rate. Mr. N. C. Howson, the managing director, said some time ago that within a few years it would not be necessary for South Africa to import tiles. The company has made coloured tiles of the types that cannot be imported under the import control restrictions. Although no competition has thus far been met from such tiles, the company has been able to keep its prices at a level at least equal to that of similar imported lines. In manufacture at the Olifantsfontein factory particular attention has been paid to "sizing" the tiles so that tilers will be satisfied with them. Only the two sizes, E and F, are being sold as first quality. Testing is carried out

periodically for "crazing resistance," in which way the company has been able to deal with many of the difficulties that arise. It is treating all the materials needed for manufacture itself.

Ceramic Strainer Cores

Ceramic strainer cores are being made in South Africa by the South African Glazing Co. (Pty) Ltd. Some time ago the first such products from this factory were tested in a number of works, and the reports from most of them were encouraging. In recent years there has been an increasing demand for ceramic strainer cores from the South African foundry industry, which has found that strainer cores made from ceramic materials have notable advantages over the more usual type strainer core made of metal or oil-sand. Cores of this type were first used overseas, and this development spurred several local foundries to seek to have the material produced in South Africa. Following the tests of the local article proving it satisfactory, it is now expected that local industry will be producing these refractory strainer cores in large quantities at competitive prices to meet the needs of local foundries.

Ceramic Insulators

A start has been made in the local production of high-tension ceramics for the electrical industry. Consolidated Rand Brick, Pottery & Lime Co. Ltd. have been making high-tension insulators for outdoor and indoor transformers for a few years now. South African Glazing Co. (Pty) Ltd. more recently signed an agreement with the Westinghouse organisation in the United States for the South African manufacture under licence of high-tension insulators. For this purpose a complete high-tension testing laboratory has been erected, and it has included among its equipment a 250,000 volt testing transformer.

High Quality Fireclays

Firebricks are being made in the Union from first-quality fireclays found within 60 miles of Johannesburg. Normal high-duty and super-duty qualities are produced in the standard brick series, as well as in special shapes. A complete range of specialities, including high-temperature bonding mortars, ramming mixtures, castable blends, plastic firebricks, maintenance coatings and insulating firebricks are also being produced. Magnesite refractories are produced from Transvaal and Rhodesian magnesite. Silica brick is available in two qualities. The normal quality is manufactured from crystalline silica, and it is stated to compare favourably with similar bricks made overseas. The

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"super duty" silica brick is made from a unique crypto-crystalline type of silica rock occurring in the Cape Province. It resembles in character the "Findlings" quartzite of Germany. The so-called "sillimanite" type of refractories are locally produced from beneficiated andalusite sands found in the Western Transvaal. South African refractories are in general found to compare favourably with similar overseas products.

High Alumina Refractory Clay

The Department of Commerce and Industries, Pretoria, reports that the mining and calcining of high alumina refractory clay occurring on a farm in the Eastern Transvaal is being undertaken by a Johannesburg firm. A typical analysis of the clay as mined is: Al_2O_3 50.4 per cent., SiO_2 45.6 per cent., Fe_2O_3 0.7 per cent., TiO_2 2.3 per cent., CaO

0.2 per cent., MgO 0.1 per cent., Alkalis 0.3 per cent., and loss on ignition 2.7 per cent. The firm states that because of exceptionally high alumina and low iron content, the clay is being exported.



P. Grant.—We have learnt with regret that Peter Grant, founder and director of the Dargavil Brickworks Ltd., Airdrie, has died at Larbert, aged 74. He was associated first with the Banknoch Coal Co. Ltd. as a salesman and in 1927 established the Dargavil Brickworks at Airdrie. He is survived by one son and a daughter.

Col. A. Stein.—Col. Alan Stein, one of the best known men in the Scottish ceramic industry, has died at his home in Polmont, Stirlingshire. He was associated all his life with the family firm of John G. Stein & Co. Ltd., firebrick manufacturers, of Bonnybridge. Serving in the First World War, he won the Military Cross, being twice wounded and twice mentioned in dispatches. In the last war he commanded the 2nd Stirlingshire Battalion of the Home Guard and was awarded the O.B.E. for his services. He had been associated with the Territorial Army since 1920, and in 1948 he was honoured by his appointment as chairman of the Stirlingshire Territorial Army Association. He was a Deputy-Lieutenant for the County of Stirlingshire.

Col. C. W. D. Rowe.—We have heard with regret of the sudden death recently of Colonel C. W. D. Rowe, C.B., M.B.E., T.D., D.L., J.P., at the age of 60. Col. Rowe was prominent in the ceramic industry, being managing director of the London Brick Co. Ltd. He had distinguished service in the First World War and after he had retired from the regular army in 1926 he played a leading part in the organisation of the T.A. and the A.C.F. in his own county, Huntingdonshire, of which he was a Deputy Lieutenant. He was High Sheriff for Cambridge and Hunts from 1947-48.

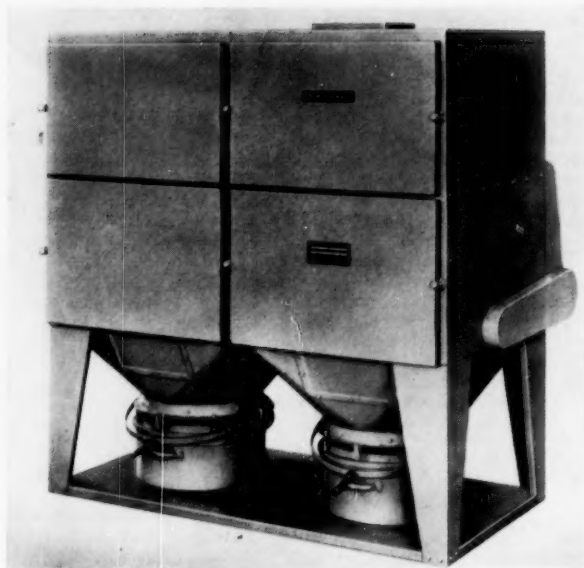
Industrial Art Bursaries Competition—1954.—The Council of the Royal Society of Arts has decided to hold a further competition among students of industrial design on the same lines as that of last year. Bursaries, of £150 each in value, will be offered for the design of domestic gas, electrical, and solid-fuel burning appliances, textiles, plastics, footwear, wall-paper and furniture, and women's fashion wear. The closing date for entries is 11th October.

Indian Ceramics.—The second number of the revived Indian ceramic journal has recently appeared. It contains articles on Copper Ruby Glass, and Raw Materials for the Refractory Industry by Dr. R. Charan and Bholanath Chatterjee respectively, and some interesting news of ceramic activities and developments in India. There is an appreciative obituary notice reviewing the great work of the late S. K. Banerjee for the Indian ceramic industry.

Honeywell-Brown Ltd.—A recent publication of Honeywell-Brown organisation contains extracts from a talk given by Henry F. Dever, president of the Brown Instruments Division of Minneapolis-Honeywell Regulator Co., before the Boston Society of Security Analysts. In his talk, Mr. Dever reviewed the question "how automatic can we get?" and drew the conclusion that the opportunities for increased instrumentation and greater automatic control are almost boundless.

A. Haslam Wood.—The Minister of Fuel and Power has appointed Mr. A. Haslam Wood, chairman and managing director of Wood Bros. Glass Co. Ltd., Barnsley, to be chairman of the East Midlands Gas Consultative Council.

Automatic shaker
applied to a Dust-
master type 201 unit
dust collector



AUTOMATIC DUST CONTROL UNIT

Unit dust collectors of the fabric type have, in the past, been designed for hand shaking of the filter media. A new device has now been designed to ensure adequate and effective shaking at pre-determined intervals, thereby eliminating the human element. This automatic shaker can be applied to the complete range of Dallow Lambert fabric type filters. It consists essentially of special control gear which governs the electrically driven shaking mechanism. The control gear is interlocked with the fan motor starter so that the shaking time cycle begins whenever the fan motor is switched off.

After an interval, during which time the fan impeller comes to rest, the

shaking mechanism comes into operation for a set period of time. As it is essential that the filter should not be shaken whilst air is passing through the fabric, the control gear is arranged so that during both the first time interval and the shaking period, and also for a short time after shaking, it is not possible to restart the fan. After the time cycle has been completed, the mechanism resets itself ready for the next operation.

As a further refinement, the electrical controls can be interlocked with the machine or operation which is being served by the dust collector. The arrangement gives the further advantage that machine, fan, and shaker controls are operated by one push-button station.

APPOINTMENT VACANT

APPPLICATIONS are invited for the position of Works Manager for a local pottery manufacturing domestic earthenware and china. This is an appointment of scope and prospect for a senior and experienced man who is capable of absolute charge of production and control of losses. Salary entirely according to ability. Apply in writing giving fullest personal details to A. G. HAYEK AND PARTNERS LTD., Management Consultants, Federation House, Stoke-on-Trent.

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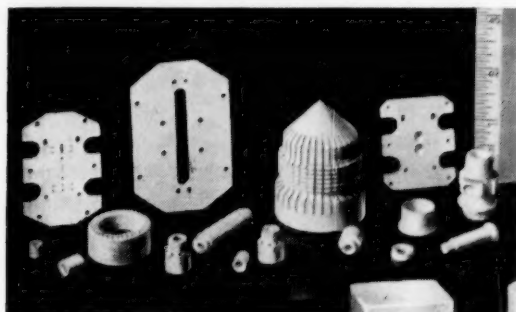
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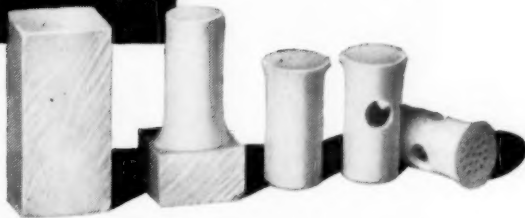


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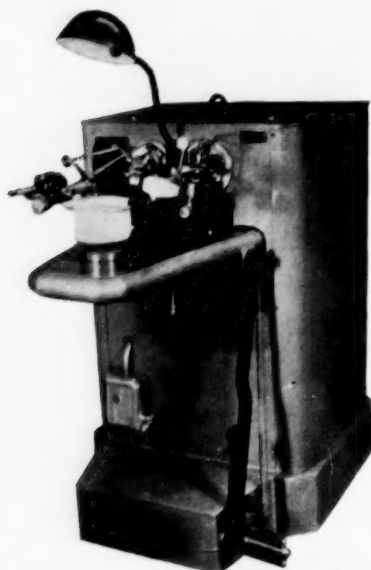


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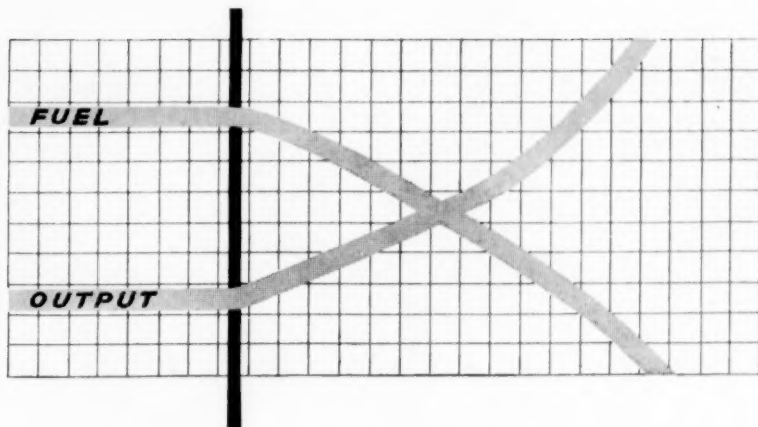
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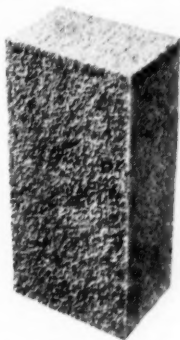
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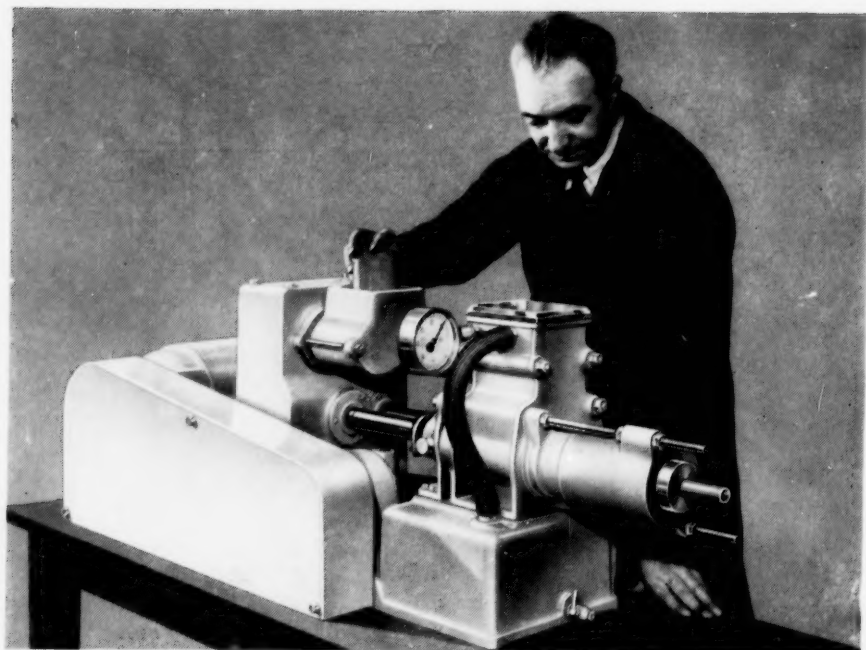
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